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I. PROPOS DE L'ÉDITEUR
I. REMARKS & NOTES BY THE EDITOR

1. Le présent numéro ouvre une nouvelle série : il est le numéro 1 de l'année VI d'existence du Bulletin.

Nous avons essayé de rendre plus complète la partie que nous avons baptisée administrative et qui est destinée à donner aux membres de l'A.I.H.S. ce qui peut retenir leur attention dans le monde hydrologique.

Comme par le passé, nous ne négligerons pas ce qui se rapporte aux travaux hydrologiques des grands organismes internationaux gouvernementaux : UNESCO, F.A.O., O.M.M., ECAFE, Centre des Nations Unies, etc.

Nous voudrions aussi avoir une partie de cette rubrique consacrée à l'action des Comités Nationaux d'Hydrologie. Le Royaume Uni nous donne aujourd'hui un magnifique exemple de semblable collaboration.

D'autre part, il nous a été demandé d'étoffer quelque peu notre partie Scientifique. Le présent numéro vous offre un nombre accru d'études présentées pour la plupart à Helsinki, mais avec un retard qui n'a pas permis de les imprimer dans les Comptes-Rendus et Rapports.

2. Le Secrétaire de l'A.I.H.S. me demande avec instance d'attirer l'attention sur un point auquel il attache une grande importance. Il vient de recevoir du British National Committee une brochure sur l'activité hydrologique dans le Royaume Uni. Cette brochure donnant les indications absolument indispensables sur tout ce qui concerne l'hydrologie est, aux yeux du Secrétaire, un modèle du genre dont il y a lieu de féliciter les auteurs mentionnés dans la préface.

1. The present issue opens a new series: it is the first issue of the sixth year of the Bulletin's existence.

We have tried to render mare complete the section which we have named Administrative and which is intended to give to the members of I.A.S.H. that which merits their attention in the realm of hydrology.

As in the past, we shall not neglect whatever concerns the hydrological activities of the great international governmental organizations: UNESCO, FAO., ECAFE, the Water Resources Development Centre (United Nations), etc.

We should also like to have a part of this section devoted to the activities of national hydrological committees. The United Kingdom has given us at this very time an admirable example of collaboration in this respect.

On the other hand, we have been asked to enlarge a little our Scientifie section. The present issue offers you an increased number of articles contributed for the most part for Helsinki, but with such delay as prevented theme being printed in the volumes of Papers and Proceedings.

2. The Secretary of I.A.S.H. entreats me to draw your attention to a matter to which he attaches great importance. He has just received from the British national committee a booklet on hydrological activities within the United Kingdom. This booklet, which gives absolutely indispensable information about everything concerning hydrology, is in the Secretary's view a model of its kind, as to which one congratulates the authors mentioned in its preface.

Nous la reproduisons in extenso dans la partie administrative réservée à l'A.I.H.S.

Le Secrétaire demande à tous les comités Nationaux de bien vouloir établir pour leur pays des documents du même genre. Peut-il espérer les recevoir avant la fin de cette année?

3. Le Secrétaire demande aussi de signaler que la publication des Rapports et Comptes-Rendus d'Helsinki a subi un certain retard du fait des événements de son pays. Le Tome troisième d'Helsinki (Erosion Continentale — Précipitations, Evaporation, etc.) a paru fin février 1961. Le tome Neiges et glaces sortira en Avril, comme vraisemblablement le volume sur l'Antarctique.

4. Le Secrétaire me transmet aussi une masse de documents relatifs à la vie de l'Association. Vous trouverez donc dans la partir dite Administrative sous la rubrique de l'A.I.H.S., les informations relatives au colloque d'Athènes et les premiers renseignements pour les colloques de 1962 sur les fluctuations des glaciers et sur l'Erosion continentale. Vous pourrez aussi prendre connaissance des thèmes à étudier pour l'Assemblée Générale de 1963.

Il est d'ailleurs question d'organiser des symposia sur d'autres thèmes à cette occasion, mais la question doit être discutée encore.

We reproduce it at full length in th Administrative section, under the heading c I.A.S.H.

The Secretary asks all national commi tees kindly to prepare each for their ow country a document of the same kind. Ca he expect to receive them before the end c this year?

3. The Secretary wishes also to announc that the publication of the Papers and Prc ceedings of Helsinki has suffered some dela owing to events in his country. The thir Helsinki volume (Land Erosion, Precipita tions, Evaporation, etc.) appeared at the en of February 1961. The Snow-and-Ice volum will appear in April, as likewise the volum about the Antarctic.

4. The Secretary has passed to me number of documents relating to the lif of the Association. You will accordingl find in the said Administrative section, unde the heading of I.A.S.H., information regar ding the Athens symposium and the firs details of the 1962 symposia, on the fluc tuations of glaciers and on land erosion You can take note also of the subjects to b discussed at the General Assembly in 1963

There is moreover a question of organi zing symposia on other subjects on th occasion of the Assembly, of 1963 but thi needs further discussion.

G. Tiso

II. PARTIE SCIENTIFIQUE
II. SCIENTIFIC PART

SUR QUELQUES RIVIERES D'UNE ABONDANCE SPÉCIFIQUE ENORME

Maurice PARDÉ (France)

RÉSUMÉ

Il y a une trentaine d'années, on s'était habitué à considérer comme des records d'abondance moyenne annuelle 40 à 45 lit/sec. par Km² pour des rivières alpestres et pyrénéennes (Gave d'Oloron) drainant de 2000 à 3500 Km², et même 6500 (cas exceptionnel) pour le Tessin. A l'issue de surfaces plus petites, on avait relevé avec admiration 60 à 70 lit/sec. par Km² pour 50 à 100 Km². et même pour 187 Km² de l'Arve à Chamonix, enfin plus de 80 ou même de 85 lit/sec. par Km² pour 5 à 20 Km² (Emissaire des lacs d'Artouste et de Caillouas, Albigna). Ensuite on a trouvé, en Ecosse, 72 lit/sec. par Km² pour 389 Km² de la Garry, 88 à 90 pour l'émissaire du Loch Quoich (128 Km²) et sur le cours de l'Isonzo (Frioul) 86 lit/sec. par Km² pour 326 Km², et 70 pour 1357 (à Canale).

Mais tous ces chiffres étaient dépassés de loin par certains modules norvégiens : par exemple 188 lit/sec. par Km² pour 83 Km² du Norddalselv, 56,1 pour 3113 Km² de la Rana.

Depuis lors on a trouvé des chiffres aussi forts ou plus élevés (compte tenu des surfaces) en diverses régions semblables à la Norvège Sud-occidentale (à des latitudes moyennes), avec reliefs condensateurs situés très près de mers tièdes d'où affluent les masses d'air humides chassées par des vents à composante Ouest. Le texte qui suit détaille divers débits qu'on a relevés ou qu'on suppute presque à coup sur pour la région côtière du Pacifique au Canada, et au Sud dans le Washington et l'Orégon septentrional, pour le Chili méridional, pour la lisière Nord occidentale de l'Ile Sud en Nouvelle Zélande. Disons seulement ici qu'au Chili le Rio San Pedro débite *124* lit/sec. par Km² pour 3690 Km², et le Rio Puelo, 78 lit/sec. par Km² pour 8832 Km². Certains petits bassins de ces régions doivent émettre 200 voire 220 lit/sec. par Km² pour 50 à 100 Km².

Pour les régions tropicales ou intertropicales, on aurait environ 240 lit/sec. par Km² à la Réunion pour la rivière des Roches et le Grand Bras (20,5 et 7,6 Km²).

Il y a vingt ans, j'ai présenté à la Sixième Assemblée Générale de l'*Association internationale d'Hydrologie* scientifique, à Edimbourg, une communication sur «les cours d'eau les mieux alimentés du monde» (1).

Depuis lors, les progrès très considérables de l'Hydrométrie dans le monde nous ont apporté des éléments de rectifications, légères en général. Et surtout ils nous ont révélé des débits moyens annuels précedemment inconnus et remarquables par leurs grandeurs. Nous indiquerons ci-dessous quelques unes de ces nouveautés, sans vouloir donner à nos énumérations et à nos explications autant d'ampleur que dans l'article plus haut rappelé.

1. — GROS DÉBITS EN EUROPE NON SCANDINAVE

Tout d'abord, et ceci nous servira de base comparative nous indiquerons quels débits moyens annuels spécifiques peuvent être considérés comme très hauts pour l'Europe en dehors de la Norvège.

On attribuera cette distinction non certes aux modules de la Seine à Paris (7 lit.sec. par km² au plus) ou de la Loire à Nantes (7,3 ou un peu plus). Bien plus imposants, pour de

(1) Comptes-Rendus et Rapports nº 22 de l'Association in-8º, 1937, p. 181-194.

grands bassins, sont les modules spécifiques virtuels (1) du Rhône à Beaucaire et du Pô à Pont Lagoscuro, à savoir respectivement 19 lit.sec. par km² pour 95.000 km², et 24,3 pour 70.000 En rapport avec ces chiffres nous citerons ceux bien plus considérables, qui se rapportent à de rivières pyrénéennes et surtout alpestres draînant 1000 à 3000 km² en général : à savoir 4 à 45 lit. sec par km² pour l'Arve à Genève, l'Aar à Berne, La Limmat à Baden, la Reuss à Mellin gen, le Gave d'Oloron à Escos, et même, chose remarquable, pour plus de 6500 km², le Tessi à la sortie du Lac Majeur (2) (44,6). On peut ajouter à cette liste l'Inn à la fin de son cours avec 28 lit.sec. par km² ou un peu plus, pour 26.000 km², encore que toute une partie intraalpin de ce bassin ne sont pas très arrosée, à cause des obstacles opposés par le relief à l'invasion de systèmes nuageux. Le Rhin a Bâle, pour 36.000 km² débite 28,5 lit.sec.par km². Et l'Aar fai un peu mieux à Stilli avec 31,6 litres seconde par km² pour 17,625 km². Si l'on prend au con traire des bassins trèspetits, on trouve pour 20 à 200 km², en assez grand nombre, des module spécifiques de 60 à 75 lit. sec. par km²; et même plus de 80 pour quelques petites surfaces ré ceptrices, dans les Pyrénées plus de 85 lit.sec. par km² pour le Sousscuéou émissaire du La d'Artouste (région supérieure du Cave d'Ossau) et de 80 pour 6 km² draînés à la sortie du La de Caillonas (bassin de la Neste de Louron).

Pour les Alpes je connaissais déjà plus de 85 lit.sec. par km² pour la Lütschine à Grindel wald (44,5 km²) et 82,9 pour l'Albigna (bassin de l'Adda) à Alpe Albigna (20,5 km²). Il s peut encore qu'on trouve 75 à 80 et plus pour l'Arveyron (80 km²) émissaire de la Mer de Glace et pour le torrent des Bossons qui draîne le glacier de ce nom. Et 68,3 lit.sec. par km² pou 205 km² de la Massa, émissaire du glacier d'Aletsch font imposante figure. Plus récemment nous avons eu connaissance de chiffres nettement plus forts, surtout compte tenu des surface réceptrices : à savoir sur l'Isonzo au Nord-Est du Frioul, 86 lit.sec. par km² à Log, pou 326 km² et 70 lit.sec. par km² pour *1357 km²* à Canale. En dehors de ces derniers cas d'abon dance réellement extraordinaire pour l'Europe continentale on peut compter comme module très élevés : 30 lit.sec. par km² pour 20.000 km², 35 pour 10.000, 45 pour 1000 à 2.000, 60 pou 250 à 500, 70 pour 50 à 100, 80 pour 10 à 50 km². Or les belles études du major MacClea ont révélé dans les hautes terres d'Ecosse extrêmement arrosées (jusqu'à 3 m 50 et plus de pré cipitations annuelles en certains points) et malgré la modération de l'altitude qui ne dépass guère 1300 mètres, certains débits encore plus remarquables que ceux des rivières alpestre (hormis le cas de l'Isonzo) pour de mêmes surfaces réceptrices.

Dans le bassin de la Ness, la Garry, pour 389 km² a débité en 15 ans 71,7 lit.sec. par km² sans doute plus que pour l'Arve à Chamonix (187 km²). Et dans le même bassin, l'émissair du Loch Quoich pour 128 km² a évacué, de 1929 à 1944 au moins 88,7 lit.sec. par km², et peut être plus de 90. Ces exemples nous rappellent que les reliefs dominant de près les mers tièdes brassées par des courants chauds et d'où viennent puissamment et souvent les vents pluvieux n'ont pas besoin d'être hauts pour condenser des précipitations très fortes et donner lieu des rivières surabondantes par leurs modules spécifiques.

2. — Norvège

Le cas de la Norvège confirme ce principe de façon éclatante. Le relief atteint au Suc 2000 à 2500 mètres, et forme une muraille condensatrice souverainement efficace. Les chiffre cités dans notre mémoire précédent (p. 8-9) subissent en général une légère réduction en s'ap pliquant à 40 ans (1900-1940) au lieu de 30 (1900-1930). Mais ils conservent une puissance tou à fait impressionnante. Le plus riche de ces cours d'eau, celui qui récemment encore tenait l premier rang dans nos registres à savoir le Norddalselv au Sud du Nordfjord débite, pou

(1) Nous appelons ainsi les chiffres obtenus après adjonctions aux débits réels, mesurés, des perte subies par le fait des irrigations, ou de dérivations diverses.

(2) Pour la plupart des rivières européennes, les modules arrêtés à 1950 ou à un millésime ultérieu sont un peu moindres que ceux qui n'englobaient point les chiffres faibles de 1942 à 1950.

83 km², 188 lit.sec. par km² (soit l'équivalent de 5 m 90 de précipitations annuelles) au lieu de 208 entre 1900 et 1930. Sans doute le chiffre tomberait-il à 160, pour 1900-1950, mais nous n'en sommes pas sûr. Nous n'avons point trouvé de documents pour le Riselev qui débitait 190 lit.sec. par km² pour 31,6 km² de 1900 à 1930.

Mais le Blaelv à Fjellhaugtwan juste à l'est du Hardangerfjord passe de 165 à 170 lit.sec. par km² pour 128 km² ce qui est formidable. Quelques autres bassins de dimensions analogues émettent plus de 100 ou de 120 lit.sec. par km². Ces faits se révèlent dans une carte des modules spécifiques au 1/1.400.000. Les foyers d'émission des débits spécifiques énormes apparaissent à proximité de la mer là où la côte est tracée du Nord au Sud, au-dessous du 62° parallèle. Outre les deux zones déjà mentionnées, les massifs situés au Sud du Sognefjord émettent encore jusqu'à 120 lit.sec. par km² et plus. Au nord, on trouve un peu plus de 100 seulement entre le 66° et le 67° parallèle, de chaque côté du Ränenfjord. Il est possible que les plus sensationnels de ces débits s'expliquent en partie par une diminution progressive des glaciers; mais nous doutons que l'alimentation exclusivement pluviale et nivale des rivières en question soit inférieure de plus de 10 ou, à la rigueur, de 20 % à celle que révèlent les chiffres présentés plus haut.

Enfin, bien que venant de *zones internes* protégées contre les vents d'Ouest, et moins arrosées que la facade, quelques rivières drainant d'assez grands bassins, comparables à ceux de l'Arve, ou de la Limmat offrent des débits supérieurs aux chiffres alpestres pour de mêmes surfaces réceptrices :

Sira à Flikkeid, 59,4 lit.sec. par km² pour 1920 km².

Rana, à Reinfosshei, 59,1 lit.sec. par km² pour 3.113 km².

Et l'on note maints chiffres relativement superbes : 60 à 80 ou 85 lit.sec. par km², pour des bassins de 350 à 800 km² et plus (1).

3. — Cote occidentale du Canada et nord-occidentale des Etats-Unis du côté du Pacifique

Et recherchant des conditions hydrométéorologiques et morphologique et des situations analogues, à savoir celles de régions montagneuses dressées au-dessus d'Océans tièdes, nous avions trouvé des débits annuels très opulents, là où nous les avions escomptés, dans les régions côtières de l'état de Washington et de l'Oregon nord-occidental aux Etats-Unis. Les chiffres dont nous disposons s'étendent maintenant jusqu'à 1953, au lieu de 1933 et 1934. Ils nous indiquent dans l'ensemble des valeurs un peu moindres que celles dont nous avons fait état (p. 6-7) dans notre précédent article, mais encore très grosses : en premier lieu, à l'extrémité occidentale des Monts Olympiens, pour la Hoh River à Spruce, 103 lit.sec. par km² pour 538 km². Ce qui implique croyons-nous, au moins 150 lit.sec. par km² pour certaines parties très arrosées de ce bassin et représentant 50 à 100 km² : Et un peu plus au Sud-Est, la Quinault, venant des mêmes montagnes témoigne d'une abondance encore supérieure avec 112 lit.sec. par km² pour *648 km²*. Pour de telles surfaces réceptrices aucune rivière norvégienne n'offre un débit égal, il s'en faut même de beaucoup.

Puis les rivières norvégiennes paraissent à peu près égalées par la Sauk, laquelle a débité 63,7 lit.sec. par km² pour 1850 km². Mais ce cours d'eau ne draine point les hauteurs les plus proches de l'Océan. Il dessert les Mont des Cacades à l'Est des Monts Olympiens, et donc sur son bassin le potentiel humide est déjà affaibli. Plus au Sud la Wilson et la Siletz desservent la chaîne côtière. La première débite 83,3 lit. sec. par km² pour 412 km², et la seconde 86,5 pour 523 km². Débits d'autant plus imposants que, depuis 15 ou 20 ans, les précipitations, dans cette zone paraissent avoir été moindres que les valeurs d'une longue période.

Au-dessous de ces latitudes, vers la Californie, l'abondance pluviale et fluviale diminue peu à peu. Mais au Nord, dans le Canada, vers Vancouver, elles doivent énormément se ren-

(1)Norges Vassdrags og Elektrisitetsvezen, Hydrografiske Undersökelser I, Oslo, 1947, 21 × 30 221 p. très abondante illustration.

forcer. Et, de fait nous avons d'abord noté avant 1940, 146 lit.sec. par km² pour la Nahmin à Vancouver (139 km²) et 172 pour 181 km² de la Stafford sur le continent tout près de l'Ile Mais voici sans doute mieux : d'octobre 1950 à septembre 1952. 274 km² de la Nascall ont débit 177 lit.sec. par km², soit plus de 200, faut-il croire pour les 50 et les 100 lit. sec. par km² les plus arrosés. Et nous ne sommes pas du tout sûr que ces années aient connu des précipitation pléthoriques. Enfin, les parties montagneuses côtières, très déchiquetées par des golfes, des détroits, des fiords, qui s'étendent plus au Nord presque vers le 60° degré sont peut-être parcourues par des rivières mieux alimentées encore.

4. — Chili méridional

Comme nous nous y attendions, les mêmes facteurs produisent les mêmes effets pour le Chili méridional, région étroite de montagnes et en certains secteurs, de collines, avant-pays qui domine de près l'Océan d'où affluent au Sud du 38° parallèle, les masses d'air humides occidentales et tièdes, en contraste avec les conditions absolument désertiques qui régnent au nord du pays [1].

Déjà nous avions eu confirmation indirecte en constatant, presque avec stupeur, vers la latitude de Valdivia, en Argentine au-delà des Andes, et donc à contre-vent pluvieux, 50 lit.sec. par km², chiffre magnifique pour 12000 km² du Limay : et 64 pour un affluent de celui-ci, le Chimehuin, à l'issue de 1011 km². Ces valeurs et d'autres analogues avaient d'avance éteint ou atténué la surprise que nous aurions pû éprouver en recevant sur diverses rivières chiliennes des données précises fournies aimablement par l'Endesa [2].

Déjà, avec 124 lit.sec. par km² pour 3690 km² (moyenne de 14 ans) le Rio San Pedro à Trafun (latitude 39°40) dans le bassin du Rio Valdivia, bat de beaucoup tous les records connus de nous, pour la même surface réceptrice. A bien réflechir, sa performance égale ou dépasse celle du Rio Petrohué au débouché du Lac de Tous les Saints, à 41°15 de latitude : à savoir 144 lit.sec. par km² en 14 ans, pour 1984 km² : L'écoulement correspondant est de 4544 millimètres ! Ce sont des chiffres qui nous auraient paru incroyables, il y a 20 ans, pour d'aussi grandes superficies. Songeons que pour un bassin de même étendue que celui de l'Arve là Génève, le Petrohué roule un débit spécifique trois fois et demi égal à celui de la rivière alpestre très réputée pour son abondance ! Enfin, un peu plus au Sud (latitude de 41°6 pour a station), le Rio Puelo, à Carrera de Basilio débite 78 lit.sec. par km² pour 8831 km² (1943-54). C'est plus de deux fois et demi le débit qu'a l'Isère pour 11.800 km².

Nous ignorons si, dans le bassin du Puelo, certaines parties, pour 2000 et 3500 km², émettent des débits comparables à ceux du Petrohué et du San Pedro. Mais nous soupçonnons que dans ces derniers domaines, quelques surfaces réceptrices de l'ordre de 50 à 100 km², peuvent débiter 180 à 200 lit.sec. par km² sinon plus. Et ce ne sont point des chiffres accrus indûment, si l'on considère le bilan moyen annuel précipitations-écoulements, par la diminution des réserves glaciaires. Ici, les glaciers n'existent point ou ne couvrent que des surfaces infimes. En effet nous constatons sur ces rivières des régimes pluviaux ou pluvio-nivaux avec maxima principaux ou uniques légèrement retardés par la traversée de lacs étendus. Pour ces régions, dans l'espace de 12 à 15 ans, les rétentions souterraines ou nivales ne peuvent plus perturber les valeurs essentielles des bilans.

Or, d'après certains indices, le flux pluvieux augmente encore plus au Sud, vers les latitudes de 43 à 46° pour lesquelles l'ile Sud de la Nouvelle Zélande, comme on va le voir, est si formidablement arrosée dans sa partie côtière Sud-Occidentale. Il n'est donc point interdit de supposer que certains bassins de 2000 et de 6000 km² dans cette zone chilienne, débiteraient plus de 160 et de 100 lit.sec. par km² respectivement, s'ils existaient. Mais au Sud du 42° degré

(1) Le Rio Pulido à Vertedero (28°) débite 0,87 lit. sec. par km² pour 2088 km².
(2) Empresa nacional de Electricidad, 920, Ramon Niéto, Santiago. Ces chiffres nous ont été envoyés par Messieurs les Ingénieurs en chefs Renato Salazar et Reinaldo Harnecker.

il n'y a plus pour eux de place, tout au moins pour ceux de plus de 1500 ou de 2000 km². Car le continent s'effrite comme au Nord de Vancouver, en îles et presqu'îles et l'espace est dévoré par les détroits, les golfes, les fiords. Cependant, il en reste assez pour que les modules spécifiques de 180 à 200 lit.sec. par km² et plus puissent s'appliquer à des surfaces de plusieurs centaines de km². Mais cela ne se réalise que si les précipitations ont bien dans ces parages, où les reliefs condensateurs Nord-Sud ne manquent point, la puissance exorbitante qui ne nous paraît pas impossible.

Nous ignorons si ces débits sont les records du monde de l'abondance fluviale pour les surfaces considérées. Car nous ne connaissons point les modules de toutes les rivières côtières occidentales du Canada. Puis il y a la Nouvelle Zélande.

5. — Nouvelle Zélande

Nous avions, en effet parié à coup sûr (pages 10 et 13 de notre précédent article) que l'île méridionale de ce dominion, prodigieusement arrosée sur toute la face nord-occidentale de la haute chaîne que borde de près presque partout l'Océan, offrait du même côté des rivières presque monstrueusement alimentées. Nous n'avons point la confirmation directe de cette surabondance. Mais pour le Sud-Est des montagnes, dans l'avant-pays, moyennement ou peu arrosé, à contre vent, nous repérons grâce à l'extrême obligeance de Mr. W.G. Newnham, Président du Soil Conservation and River Control Council, à Wellington, des chiffres aussi révélateurs que les débits du Limay ou de ses tributaires pour la région transandine, à l'Est des rivières chiliennes si pléthoriques. L'émissaire du Lac Wakatipu (latitude de 45°) roule 57 lit.sec. par km² pour 2980 km², en un lieu où les précipitations annuelles n'atteignent déjà plus 1 mètre. A son débouché encore moins arrosé, vers le 44° degré, le lac Pukaki fournit 100 lit.sec. par km² pour 1354 km², ce qui est relativement fantastique. Enfin le Lac Wanaka à mi-chemin entre le 44° et le 45° degré, envoie dans son exutoire le module aussi honorable, vue la surface drainée (2545 km²) de 83 lit.sec. par km².

Or, à 120 kilomètres à l'Ouest exactement, à Milford Sound, la précipitation annuelle représente 6 m 43. Et l'excellent hydrilogue M. Ellis C. Schnackenberg (1) ne juge pas du tout impossible que les chutes soient plus fortes. La chose nous paraît très probable, même si, comme nous le croyons, l'optimum pluvial, aussi près des cotes, se situe non pas à de grandes altitudes, vers les cimes, mais au-dessous de 2000 ou même de 1500 mètres. En tous cas, la carte des précipitations annuelles néo-zélandaises préparée par M.C.J. Seelye (2) montre sur presque toute la longueur de la grande chaîne une bande de terrain large de 25 à 30 kilomètres, au Sud du 44° parallèle où les chutes d'eau dépassent 5 mètres.

De ce côté, à vrai dire, il n'y a pour ainsi dire point de place pour des bassins fluviaux autres qu'étriqués ou lacérés. Et même une notable partie de l'espace compris entre les plus hautes montagnes et la mer est, encore ici rongée par les fiords. Il ne reste donc que des surfaces réceptrices de quelques centaines, voire quelques dizaines de km² pour chaque cours d'eau. Cependant, peut-être 800 ou 1000 km² aboutissent à la rivière Hollyford près de Milford Sound. Malgré une certaine protection, à l'ouest contre les influences pluvieuses, il ne nous étonnerait point que ce bassin débite quelque 150 à 180 lit.sec. par km² sinon plus. Mêmes suppositions pour la Haast-River, plus au Nord-Est (plus de 1000 km²). Mais sur la même cote, de petits cours d'eau amènent peut-être aux fiords, ou directement à l'Océan 200 à 225 lit.sec. par km² ou plus.

(1) Dans une note dactylographiée non publiée.
(2) Maps of average rainfall in New-Zealand, New-Zealand Meteorological Service, Wellington 1945, 16 cartes en 1 brochure de 20 × 30 cm.

6. — RIVIÈRES TROPICALES ET INTERTROPICALES

Nous avons pensé autrefois que les cours d'eau les plus riches du monde, en abondance spécifique, étaient ceux que nourrissent certaines pluies intertropicales fameuses comme celles de Tcherrapoundji dans l'Assem (plus de 11 m 50 par an à la latitude de 25°3) et celles de Waialcale dans Hawaï (près de 12 mètres par an, vers le 20° degré). Cependant, les chiffres du Geological Survey, relatifs aux rivières d'Hawaï ne nous indiquent nulle part plus de 120 à 150 lit.sec. par km^2 pour des bassins compris entre 10 et 20 km^2.

A l'issue de surfaces réceptrices infimes, par contre, on aurait dans l'île de Maui des débits encore inconnus de nous pour tous autres lieux jusqu'à une date récente; par exemple 221 lit. sec. par km^2, pour 1,815 km^2 (rivière West Waibuanui); et pour la «rivière» Alo 408 lit. sec. par km^2, pour un peu plus de 0,5 km^2. Ce débit, le record du monde de beaucoup à notre connaissance, correspond à 12 m 85 de pluies écoulées, soit à environ 14 mètres de pluies tombées. Mais est-il authentique ? Et la signification du module brut correspondant ne risque-t-elle point d'être faussée par des apports souterrains extérieurs, en une île où la perméabilité des terrains volcaniques peut se prêter à de telles supercheries (1)

Et nous nous demandions si de semblables phénomènes ne renforçaient point frauduleusement les modules spécifiques prodigieux que nous allons dire, et qui s'appliquent à deux petits cours d'eau de la Réunion, jaugés par les ingénieurs de la Section Hydrologique de l'O.R.S.T.O.M. (Office de la Recherche Scientifique et Technique d'Outre Mer) sous la savante et dynamique direction de M. Jean RODIER.

On aurait donc eu, en 7 ans, 293 lit.sec. par km^2 pour 20,5 km^2 de la Rivière des Roches, et 298 pour un affluent, la Rivière du Grand Bras, de 1951 à 1954, à l'issue de 7,6 km^2. Et rien ne nous prouve que la pluviosité des années en question aurait été excessive. On aurait plutôt des indices du contraire. Cependant, une partie notable des volumes liquides annuels consiste en crues très fréquentes, souvent démesurées, et qui auraient par exemple roulé jusqu'à 750 mc (pour 20,5 km^2) sur la Rivière des Roches. Les débits supérieurs à 50 ou 70 mc. sont là chiffres peu courants.

Mais l'Annuaire hydrologique de 1957 supprime en grande partie notre enthousiasme en nous présentant des surfaces réceptrices augmentées; 24,4 et 8,9 km^2. De ce fait les modules en question tombent respectivement à 247 et 242 lit./sec. par km^2.

(1) Ils peuvent affaiblir aussi beaucoup certains écoulements apparents, au détriment de l'opinion qu'on devrait avoir sur l'abondance spécifique. Puis pour beaucoup de petits bassins des îles Hawaï, on donne les débits bruts mais point les surfaces.

THE MECHANISM OF LONGITUDINAL DIFFUSION IN A TIDAL RIVER

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ABSTRACT

The intrusion of seawater in a tidal river is treated as a diffusion problem, characterized by a coefficient of longitudinal diffusivity.

In order to analyse the longitudinal diffusivity, a mathematical model is set up, consisting of two bodies of water, either one besides the other or one on top of the other. The two bodies are assumed to move relatively to each other, as a secondary effect of the tidal flow. It is moreover assumed that there is turbulent exchange of salt between the bodies.

It is demonstrated that the diffusion of salt into the river is greatest for an optimum value of the coefficient of exchange between the two bodies.

Exchange weaker or stronger than this optimum both diminish the salt intrusion.

The theory is applied to the Rotterdam Waterway, for which estimates of the exchange are made. Estimation of the reduction of the turbulence by stratification and hence of the vertical exchange, shows that the observed strong intrusion is explainable.

Intensified vertical mixing, for instance as provoked by compressed air, need not always result in less intrusion, and hence should be considered carefully.

RÉSUMÉ

La pénétration de l'eau de mer dans une rivière à marée est traitée comme un problème de diffusion caractérisé par un coefficient de diffusion longitudinal.

Afin d'analyser la diffusion longitudinale, un modèle mathématique est établi, consistant en deux masses d'eau, soit l'une près de l'autre, soit l'une au-dessus de l'autre. Les deux masses sont supposées se déplacer l'une par rapport à l'autre comme effet au courant de marée. On suppose de plus qu'il existe un échange turbulent de sel entre les deux masses.

On démontre que la diffusion de sel dans la rivière est la plus grande pour un valeur optimum du coefficient d'échange entre les deux masses.

Des échanges plus faibles ou plus intenses que cet optimum diminuent la pénétration de sel.

La théorie est appliquée au Canal reliant Rotterdam à la Mer pour lequel des estimations de l'échange sont faites, L'estimation de la réduction de la turbulence par stratification et par suite de l'échange vertical, montre que la forte pénétration observée est explicable.

Un mélange vertical intensifié, par exemple par introduction d'air comprimé, ne conduit pas nécessairement à une réduction de la pénétration de sel et doit par conséquent être considérée avec attention.

1. INTRODUCTION

In a tidal river the mean distribution of the salinity is determined by the equilibrium of the intrusion of the salt from the sea with the expulsive action of the fresh water discharge. A simple mathematical model of this equilibrium is obtained as follows:

The transport of salt is composed of an advectional part and a part caused by diffusion.

The mean advectional transport through a cross-section of the tidal river is the product of the mean salt concentration $\bar{z}$ in that cross-section and the fresh water discharge Q_0. Here we understand by the mean concentration the average over one tidal period. The transport $Q_0\bar{z}$ is towards the sea.

The mean diffusive transport is more difficult to formulate. It is clear, however, that the general tendency is a transport from higher to lower mean concentrations. Hence we may account for this transport by putting it proportional to the gradient of the mean concentration:

$$\mathscr{A}\mathscr{D}\frac{d\bar{z}}{dx}$$

Here x is the coordinate along the river; the positive x-axis is directed towards the sea. Furthermore $\mathscr{A}$ is the mean area of the cross-section and $\mathscr{D}$ is the longitudinal diffusivity. The mean diffusive transport is in the direction from the sea, up the river.

When the mean distribution is in equilibrium, the two transports must cancel each other:

$$Q_0\bar{z} = \mathscr{A}\mathscr{D}\frac{d\bar{z}}{dx}. \tag{1}$$

When we assume that $\mathscr{A}$ and $\mathscr{D}$ are known as functions of x, this equation can be solved, when the mean concentration in one cross-section is known, say $\bar{z}_0$ for $x = x_0$. Then

$$\bar{z}(x) = \bar{z}_0 \exp -Q_0 \int_x^{x_0} \frac{dx}{\mathscr{A}(x)\,\mathscr{D}(x)}. \tag{2}$$

We have now to consider more closely the longitudinal diffusivity $\mathscr{D}$.

Observed salt distributions in rivers indicate that longitudinal diffusivity is much greater than diffusivities found in the field of turbulence provoked by the bottom friction. Hence we must consider other patterns of mixing movements.

Diffusivity can generally be described as the product of a mixing path and a mixing velocity. Now Arons and Stommel have related the longitudinal diffusion to the tidal movement, by putting the mixing path proportional to the tidal excursion path $2\hat{x}$, and the mixing velocity proportional to the tidal velocity amplitude $\hat{v}$:

$$\mathscr{D} = 2\lambda\hat{x}\hat{v}. \tag{3}$$

Here λ is a parameter depending on further characteristics of the tidal regime.

The present paper aims at penetrating somewhat deeper into these tidal mixing movements.

2. Tidal mixing movements

The tidal motion in a river consists primarily of shifting of the body of water alternatively up and down the river and compressing and expanding of this body alternatively. The shifting motion is observed as a tidal current, whereas the compressions and expansions are revealed by the rising and falling of the water surface.

These primary movements can not produce any mixing.

Attending these primary movements however, secondary movements are possible, by which mixing and diffusive intrusion may be provoked.

Diffusive intrusion may for instance result from the presence of such basins as harbours, communicating with the river. The diffusion mechanism can be explained as follows:

When the river is more saline than the basin, density currents through the entrance of the basin will be set up, so that the salter river water enters the basin, whereas the relatively fresh water is expelled to the river. This results in a net transport of salt from the river to the basin.

In a similar way there will be a net transport of salt from the basin to the river, when the basin is more saline than the river.

Now the salinity of the river will be highest near the end of the flood and lowest near the end of the ebb. Hence the basin will take up salt from the river during an interval of time about the end of the flood, and it will render this salt again during an interval of time about the end of the ebb.

When we consider the salt taken up at the end of one flood period, this salt is stored in the basin during the following ebb. Then it joins again the waterbody in the river and during the next flood it is transported up the river.

Hence, during one tidal period, the quantity of salt considered appears to have undergone an upward displacement along the river.

This diffusive intrusion apparently results from the combination of firstly a relative motion of the waterbody in the river and the water body in the basin, and secondly the exchange of salt between these two waterbodies in the direction of the salinity gradient.

Apart from density currents, the requisite exchange may also be obtained by the flood and ebb currents in the entrance of the basin, provided there is a sufficient phase lag between these currents and the tidal currents in the river.

A similar diffusive mechanism is formed by the relative motion of the waterbody along the axis of the channel and the more slowly moving water masses near the shores. There is exchange between the two bodies as a result of lateral diffusion.

In many rivermouths the fresh water flows to sea over a salt water wedge intruding from the sea on the bottom of the river. The tidal motion of the salt layer is different from that of the fresh layer.

When there is mixing between the two layers, salt will penetrate into the river water so that this water gradually becomes more saline when it approaches the sea.

When the layers have an oscillating relative motion, the intensity of the exchange between the layers also oscillates. The variations in this exchange combined with the relative oscillating motion of the layers, further increases the intrusion of salt.

In order to investigate these intrusion mechanisms more thoroughly, we shall set up the mathematical model of a system of two bodies of water stretched along the river, subjected to different movements, with different salinities, and with exchange of salt between them.

3. Equations of a system of two moving strips

We simplify the problem by dividing the river water into two bodies or strips with cross-sections $\mathscr{A}_a$ and $\mathscr{A}_b$ respectively. The first strip may have the velocity v_a and the second strip the velocity v_b. The average concentration in the first strip be z_a and in the second strip z_b.

For both strips we can set up a continuity equation of the salt. This equation takes the form

$$\frac{\partial}{\partial x}(v_a \mathscr{A}_a z_a) + \frac{\partial}{\partial t}(\mathscr{A}_a z_a) + \mathscr{E} = 0 \tag{4}$$

for the first strip. Here $\mathscr{E}$ is the transport of salt from the first to the second strip, per unit time and per unit length of the river.

An equation analogous to (4) is valid for the second strip.

We shall assume that, in addition to the movement of the bodies, there is also turbulence provoking diffusion of salt from one body to the other. Let there be a transition zone between the bodies with a thickness a, so that

$$\frac{z_a - z_b}{a}$$

is a fair estimate of the salinity gradient in the transition zone. Then

$$\mathscr{E} = \mathscr{D}_t b \, \frac{z_a - z_b}{a},$$

when $\mathscr{D}_t$ is the diffusivity for transverse diffusion through the transition zone. The cross-sectic of the transition zone $= ba$.

When the strips represent two lanes separated by a vertical plane, b denotes the depth the river and a is the width of the transition zone, whereas $\mathscr{D}_t$ stands for the horizontal cros diffusivity.

When the strips represent two layers separated by a horizontal plane, b denotes the widt of the river and a is the height of the transition zone, whereas $\mathscr{D}_t$ then stands for the vertic diffusivity.

In order to focus our attention on the more important aspects of the problem, we loc apart from the variations of $\mathscr{A}_a$ or $\mathscr{A}_b$ with x and t and also from the variations of v_a or with x.

Then we obtain the two equations

$$v_a \frac{\partial z_a}{\partial x} + \frac{\partial z_a}{\partial t} + \frac{\mathscr{A}_b}{\mathscr{A}} \alpha (z_a - z_b) = 0 \tag{5}$$

$$v_b \frac{\partial z_b}{\partial x} + \frac{\partial z_b}{\partial t} + \frac{\mathscr{A}_a}{\mathscr{A}} \alpha (z_b - z_a) = 0, \tag{6}$$

where

$$\alpha = \frac{\mathscr{D}_t b}{a} \, \frac{\mathscr{A}}{\mathscr{A}_a \mathscr{A}_b}, \tag{7}$$

when $\mathscr{A}$ denotes $\mathscr{A}_a + \mathscr{A}_b$.

The physical meaning of α becomes clear when we consider the case that z_a and z_b ar independent of x. Then subtracting (6) from (5) yields

$$\frac{\partial}{\partial t}(z_a - z_b) + \alpha (z_a - z_b) = 0,$$

with the solution

$$z_a - z_b = \mathscr{C} e^{-\alpha t}$$

Hence $1/\alpha$ is the time constant of the exchange of salt between the two strips.

By introducing the mean concentration z and half the concentration difference y,

$$x = \frac{\mathscr{A}_a z_a + \mathscr{A}_b z_b}{\mathscr{A}} \text{ and } y = \frac{z_a - z_b}{2}$$

we can derive from (5) and (6)

$$v \frac{\partial z}{\partial x} + u' \frac{\partial y}{\partial x} + \frac{\partial z}{\partial t} = 0 \tag{7}$$

$$v' \frac{\partial y}{\partial x} + u \frac{\partial z}{\partial x} + \frac{\partial y}{\partial t} + \alpha y = 0, \tag{8}$$

where

$$v = \frac{\mathscr{A}_a v_a + \mathscr{A}_b v_b}{\mathscr{A}}; \; u = \frac{v_a - v_b}{2};$$

$$v' = \frac{\mathscr{A}_b v_b + \mathscr{A}_a v_b}{\mathscr{A}}; \; u' = \frac{4 \mathscr{A}_a \mathscr{A}_b}{\mathscr{A}^2} u.$$

. Diffusion by uniformly moving strips

When v_a and v_b are constant, solutions of (7) and (8) can be found, for which z and y re independent of t. These solutions represent the permanent distributions in a system of wo uniformly moving strips.

By integration of (7) we find that the total transport of salt,

$$\mathcal{T} = \mathcal{A}_a v_a z_a + \mathcal{A}_b v_b z_b = \mathcal{A}(vz + u'y),$$

n this case must be constant:

$$\mathcal{A}(vz + u'y) = \mathcal{T} = \text{constant.} \tag{9}$$

Eliminating y from (9) and (8) and integrating then yields

$$z = \frac{\mathcal{T}}{\mathcal{A}v} + \mathcal{C} \exp \frac{ax}{uu' - vv'} \tag{10}$$

More in particular we have

$$z = \mathcal{C} \exp \frac{ax}{uu' - vv'} \tag{11}$$

when the total transport is zero, as we may assume in case of a river discharge of purely fresh water.

Comparing the solution (11) with the solution (11) shows that the longitudinal diffusivity n this case may be defined by

$$\mathcal{D} = \frac{uu' - vv'}{a} = \frac{-v_a v_b}{a}. \tag{12}$$

When it is assumed that the strips move in opposite directions v_a and v_b have different signs nd $\mathcal{D}$ is positive, as to be expected.

A somewhat more convincing demonstration of the diffusive character of the two strips mechanism can be given by the following example:

Essential for the diffusive property is the relative motion of the strips and the exchange between them. Therefore we now confine ourselves to the case that both strips move with the velocity u, in opposite directions, and that $\mathcal{A}_a = \mathcal{A}_b$. Then $v = v' = o$ and $u' = u$.

Elimination of y from (7) and (8) yields

$$\frac{\partial^2 z}{\partial x^2} - \frac{a}{u^2}\frac{\partial z}{\partial t} - \frac{1}{u^2}\frac{\partial^2 z}{\partial t^2} = 0. \tag{13}$$

For slowly varying distributions we might suppose that the second derivative with respect o t would be negligible, so that (13) reduces to

$$\frac{\partial^2 z}{\partial x^2} = \frac{a}{u^2}\frac{\partial z}{\partial t} \tag{14}$$

On the other hand the equation for diffusion in a one-dimensional medium is

$$\mathcal{D}\frac{\partial^2 z}{\partial x^2} = \frac{\partial z}{\partial t}, \tag{15}$$

so that comparison of (14) and (15) leads to the presumption that the system of the two strips approaches more or less the behaviour of a medium with a diffusivity

$$\mathcal{D} = \frac{u^2}{a}. \tag{16}$$

This presumption is supported by considering the exact solution of (13) for the distributio
resulting from releasing a quantity of salt $\mathscr{C}$ in the instant $t = o$ at $x = o$.
Hence we may put

$$z = \frac{\mathscr{C}}{\mathscr{A}} \delta(x) \text{ and } y = 0 \text{ for } t = 0,$$

when $\delta(x)$ denotes Dirac's impulse function.

For these initial conditions (13) can be solved in terms of Bessel functions (ref. [3]). Th asymptotic expansion of this exact solution, for larger t, is

$$z = \frac{\mathscr{C}}{\mathscr{A}} \sqrt{\frac{a}{4\pi u^2 t}} \exp - \frac{ax^2}{4u^2 t}, \tag{17}$$

which is just the solution of (15) for the same initial conditions, provided we adopt (16).

This indicates that the mechanism of the two moving strips diffuses in a similar way a a medium obeying an equation like (15). Especially the later stages of the history of a distri bution are almost equal.

It is to be observed that the effective longitudinal diffusion is inverse proportional to and hence to $\mathscr{G}_t$ (cf. (7)). Hence a small transverse diffusivity is favourable to create a larg longitudinal diffusivity. This can be explained as follows:

As we saw in section 3, the time constant of the exchange between the strips is $1/a$. Henc quantities of salt picked up by one strip from the other and rendered back some time after wards, have a mean sojourn time of the order of $1/a$. During this mean sojourn time the strip are displaced relatively by a distance of the order u/a, so that we may introduce

$$l = \frac{u}{a}$$

as a mixing path of the longitudinal diffusion. Then

$$\mathscr{D} = lu$$

takes the orthodox form of a diffusivity as the product of the mixing length l and the mixin velocity u.

It is now clear that, when the exchange diminishes, the sojourns are prolonged and henc the mixing length and the diffusivity increase.

5. Diffusion by strips moving periodically

We shall now confine ourselves to the case that $A_a = A_b$ and hence $v' = v$ and $u' = u$

In order to account for the tidal motion, we suppose that v and u are periodic function of the time:

$$v = v_0 + \hat{v} \cos \omega t \tag{18}$$

$$u = u_0 + \hat{u} \cos (\omega t + \varphi). \tag{19}$$

Then z and y will likewise be periodic functions of the time, which can be expanded by fourier series:

$$z = z_0 + z_1 e^{i\omega t} + z_{-1} e^{-i\omega t} + z_2 e^{2i\omega t} + \ldots \tag{20}$$

$$y = y_0 + y_1 e^{i\omega t} + y_{-1} e^{-i\omega t} + \ldots \tag{21}$$

ere z_0, y_0, z_1 etc. are functions of x. The coefficients z_0 and y_0 are real. The other coefficients e complex; z_n and z_{-n} are conjugated, like y_n and y_{-n} .

By a well-known procedure (ref. [3]) we can deduce from (7) and (8) a series of simultaneous ferential equations in the functions z_0, y_0 etc. of the form

$$i\omega n z_n + \hat{v}_0 z'_n + \tfrac{1}{2}\hat{v} z'_{n-1} + \tfrac{1}{2}\hat{v} z'_{n+1} + u_0 y'_n + \tfrac{1}{2}\hat{u} e^{i\varphi} y'_{n-1} + \tfrac{1}{2}\hat{u} e^{-i\varphi} y'_{n+1} = 0, \tag{2)}$$

$$i\omega n y_n + v_0 y'_n + \tfrac{1}{2}\hat{v} y'_{n-1} + \tfrac{1}{2}\hat{v} y'_{n+1} + u_0 z'_n + \tfrac{1}{2}\hat{u} e^{i\varphi} z'_{n-1} + \tfrac{1}{2}\hat{u} e^{-i\varphi} z'_{n+1} + a y_n = 0. \tag{3)}$$

ere n assumes all the integral values, positive and negative. Accents denote differentiations ith respect to x.

In order to obtain a tractable result, we neglect in (20) and (21) the terms with exponents ω, 3ω, etc. The six functions z_0, y_0 z_1, y_1, z_{-1} and y_{-1} are then defined by six linear equations otained by substituting n -- 1, 0, −1 in (22) and in (23).

We pursue the solution in terms of exponential functions

$$z_0 = \mathscr{C}_0 e^{kx}$$

$$z_1 = \mathscr{C}_1 e^{kx}$$

Ve then arrive at a characteristic equation in k of the fifth degree.

The smallest root k of this quintic is the most interesting for our purpose, since this root efines the asymptotic behaviour of z_0, y_0 etc. for x tending to minus infinity, i.e. for oing up the river.

In order to obtain a discussable result we shall admit some simplifications.

We shall investigate the diffusion in relation to a coordinate system of which the origin ollows the mean tidal motion. Then $\hat{v} = 0$.

The influence of a permanent relative motion has been discussed already in section 4 Hence we shall now put $u_0 = 0$.

Then, for small $v_0/\hat{u}$, the approximation

$$z_0 \approx \mathscr{C}_0 \exp \frac{2v_0}{u^2} \frac{\alpha^2 + \omega^2}{\alpha} \tag{24)}$$

s valid, for the distribution of the mean samlinity z_0 along the river.

Comparison with (2) shows that the longitudinal diffusivity can now be defined by

$$\mathscr{D} = \tfrac{1}{2}\hat{u}^2 \frac{\alpha}{\alpha^2 + \omega^2}$$

For values of α great compared to ω, we have approximately

$$\mathscr{D} \approx \tfrac{1}{2}\hat{u}^2/\alpha.$$

This is the same expression as (16) if we substitute the effective oscillatory velocity $\hat{u}/\sqrt{2}$ for u.

Resolving $\mathscr{D}$ into a mixing length and a mixing velocity, as in the preceding section, we may put

$$l = \frac{\hat{u}}{\sqrt{2}} \frac{\alpha}{\alpha^2 + \omega^2}. \tag{26}$$

This mixing length varies approximately inverse proportional to α for great α compared to ω approximately direct proportional for small α and it attains a maximum value

$$l_{\max} = \frac{1}{2}\hat{u}/\omega\sqrt{2} = \frac{1}{4}\sqrt{2}\,\mathscr{L} \tag{27}$$

when $\alpha = \omega$. Here $\mathscr{L} = 2\hat{u}/\omega$ is the relative tidal excursion path.

In order to explain this result we have to bear in mind that the mixing length depends o the time of sojourn of salt masses in one of the strips. When $\alpha \gg \omega$ the mean time of sojour is small compared to the tidal period, whereas for $\alpha \ll \omega$ the time of sojourn is much greate

Now it is clear that, as long as the time of sojourn is much shorter than the tidal perio increasing of the time of sojourn results in greater relative displacements of parcels of sal These displacements however, can at most be equal to the relative tidal excursion path, whe the time of sojourn is just one half tidal period. For greater times of sojourn the relative di placements become less again.

Hence, when the mean time of sojourn approaches the tidal period, the mixing lengt tends to a maximum, which is a definite fraction of the relative tidal excursion path, as define by (27).

When the average time of sojourn is much greater than the tidal period, the effectiv displacements become less again and the mixing length, which is an average of these displac ments, decreases.

6. Longitudinal diffusion in the Rotterdam Waterway

Through the Rotterdam Waterway the discharges of the rivers Nieuwe Maas and Oud Maas are carried to the North Sea and meanwhile the sea water can intrude these rivers.

The salinity distributions in this river system have been investigated by applying the mathe matical model of section 1 to the available observations. The results of this investigation ar published elsewhere (ref. [4]). Here we shall try to use the observational evidence to explore th mechanism of diffusion.

Although observations of the three rivers are available, the most appropriate data fo our present purpose refer to the lower Waterway, between the confluence of the Oude an Nieuwe Maas and the sea. This river forms a rather regular channel with only some small har bour basins communicating with it.

There is a rather strong stratification in this river and at the beginning of the flood curren period the upper fresh water layers and the lower sea water layers have appreciably differen motions.

There also exist transverse gradients of salinity and velocity.

Hence it appears that relative motions of layers, as well as that of lanes, should accoun predominantly for the longitudinal diffusion in this river.

The diffusivity could be estimated from the observations, and amounted to about 80 m^2/s on the average, with a significant increase with increasing tidal range, viz. about propor tional to this range.

Now we infer from (25) that the longitudinal diffusivity $\mathscr{D}$ is proportional to the squar of the relative tidal velocity amplitude $\hat{u}$. It is to be expected that $\hat{u}$ increases when the tida range increases, but it is likely that $\hat{u}$ is less than proportional to the tidal range, mainly becaus a stronger tidal motion produces greater mixing, so that the density differences, driving th relative motion, decrease.

Hence a variation of $\mathscr{D}$ proportional with the range seems plausible.

Quantitatively (25) can not yet account sufficiently for the observed diffusivity. Let fo instance $\hat{u}$ be 0.2 m/s. Then $\mathscr{D}$ becomes about 150 m/s for ω = 0.14 mrad/s, which is still som 5 times less than the observed value.

Now (25) accounts only for the diffusive effect of the oscillatory relative motion. In fact there is also some permanent relative motion, as discussed in section 4.

Moreover there is the obvious limitation to (25), that we schematized the river as consisting of only two bodies of water. In fact there are a multitude of relative motions, not only as superimposed layers, but also as juxtaposed lanes.

By applying the method of section 4 to systems of three or more strips, it is found that such a subdividing may yield several times greater values for the longitudinal diffusivity.

It was assumed above, that α is approximately equal to ω. This has still to be verified.

When we consider the shear motion associated with the vertical velocity distribution, we may schematize by two layers, between which salt may be exchanged by the turbulence generated by friction at the bottom.

In weakly stratified flow we can define $\mathscr{D}_t$ by

$$\mathscr{D}_t = l^2 \left|\frac{dv}{dz}\right| ,$$

where l is the mixing length and dv/dz the vertical gradient of the horizontal velocity. Adopting Bakmeteff's expression for l together with the exponential velocity distribution, we obtain at mid-depth

$$\mathscr{D}_t = \tfrac{1}{4} \mathscr{K} . d . v_*$$

where $\mathscr{K}$ is von Karman's coefficient (≈ 0.4), d the depth and v_* the friction velocity.

Then, by (7), where we put $\mathscr{A}_a = \mathscr{A}_b = a.b$ and $a = \frac{1}{2} d$, we arrive at

$$\alpha = 2 \mathscr{K} \frac{v_*}{d} .$$

With e.g. $v_* = 0.15$ m/s and $d = 12$ m this yields about $\alpha = 0.01$, that is about 70 times ω. Then according to (25) we would obtain a longitudinal diffusivity of a few m^2/s.

However, the stratification in the Waterway is so marked, that the vertical diffusivity $\mathscr{D}_t$ is much less than it would be in unstratified flow. As far as we know, the reduction in $\mathscr{D}_t$ may quite well be so great as to make α approximately equal to ω.

Altogether the observed longitudinal diffusivity seems well explainable as the result of a combination of mixing movements resulting from tidal entrainment and density differences.

The formula (25) casts a clarifying light on the method of salt repulsion by artificially increased mixing.

The basic idea of this method is to prevent salt intrusion by mixing the intruding sea water with the outflowing fresh water, for instance by means of an air bubble screen.

Formula (25) shows, however, that the method will not always be successful.

Intensified mixing generally increases α. Now, when $\alpha \gg \omega$, the diffusion decreases when α becomes greater. But, when $\alpha \ll \omega$, an increase of α results in a greater diffusion. When $\alpha \approx \omega$, an appreciable decrease of the diffusion can only be obtained by a rather great increase of α.

When our presumption, that in the lower Waterway α is of the same order as ω, is right, the effect of an artificially increased mixing is uncertain.

Further up the river the influence of the stratification diminishes. However, in that region, and in particular in the Nieuwe Maas, mixing by harbour basins becomes important. This mechanism has not yet been studied in more detail.

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LAWS OF THE FORMATION OF MINIMUM STREAM FLOW

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In the U.S.S.R. the concept of minimum flow includes various characteristics of low stream flow (absolute minimums, daily and monthly values of minimum flow for each year separately for winter and summer, normal values of daily and monthly minimum flow). Minimum flow is an important element of the hydrologic regime of a river.

The knowledge of the nature of minimum stream flow is founded on establishing the laws of stream-flow derived from ground water sources («base flow») in connection with the physiography of the territory. The presence of genetic connection between minimum stream flow and base flow is determined by the fact that minimum stream flow is to be observed at the time of low water when rivers are fed by base flow. Thus, base flow is the decisive factor in the formation of minimum flow. The conditions of base flow and its intensity are determined by the characteristics of the regime of ground water as well as by the character of the inter-relation of the latter with river water. Therefore, in respect of establishing laws of the formation of minimum stream flow in the U.S.S.R., of great importance are investigations conducted by Soviet hydrogeologists who, proceeding from the concept of geographical zonality of natural phenomena, have established a series of general laws of ground water formation in their inter-relation with river waters.

It is known that the external manifestation of the geographical zonality law is to be observed in a regular character of distribution over the Earth's surface of thermal conditions, precipitation, soil and vegetal cover, as well as of other elements of the landscape which, being inter-related, combine to create latitudinal (geographical) zones; closely associated with this combination of physiographical components is the distribution over the territory of the conditions of ground-water formation.

This association is to be explained by the fact that the water in the upper layers of the earth's crust, being an integral element of the geographical landscape, is affected by all processes taking place on the earth's surface. The intensity of the effect, naturally, decreases with depth: the easiest exchange and the closest interaction with the processes on the earth's surface are characteristic for the waters of the so-called «active water-exchange zone», i.e. waters occurring at the base level of rivers or above, among which ground water is singled out as the main source of feeding the rivers.

Geographical zonality also influences the character of the vertical distribution of underground water accumulations in the earth's crust, which varies with the character of the influence of the geographical complex in various geographical zones, as the depth of the occurrence of various types of ground water changes in accordance with the changing geographical zones.

Laws associated with the geographical zonality of natural phenomena served as a scientific basis for developing a principal scheme of ground water regions (B.L. Lichkov, 1933) and compiling ground-water maps (V.S. Ilyin, 1925; O.K. Lange. 1947).

A series of existing summaries of regional hydrogeological division for separate areas of the U.S.S.R. reflect to a certain degree such characteristics of ground water regime as are associated with the geographical features of the territory.

Developing B.L. Lichkov's conceptions of the laws of hydrodynamic separation of ground waters, F.A. Makarenko (1948) has indentified three well-pronounced vertical zones of ground water flow:

(1) upper zone of active flow, whose geographical zonality coincides with climatic belts. The lower boundary of this zone coincides with the local base levels of rivers;

(2) medium zone of delayed flow, subject to lesser climatic effect but also geographically zonal. The lower boundary of this zone is the base level of large rivers.

(3) lower zone (of relatively stagnant water), geographically azonal and lying below the base level of large stream systems.

The established laws of ground-water formation offer a basis for studying the genetic characteristics of minimum flow.

Hydrological investigations in which the genesis of minimum flow was considered with due regard for base flow, have revealed a series of laws in the formation of low (minimum) flow.

M.P. Raspopov (1950), using the general principles of the classification of ground water occurring in the zone of active water-exchange (B.L. Lichkov, F.A. Makarenko, B.I. Kondein), obtained more exact data on the regime characteristics of ground water flow into streams with reference to the plain territory of the European part of the U.S.S.R. He assumed that two principal types of water of the active water-exchange zone play the predominant role in the ground water flow into streams on the afore-mentioned territory, viz. :

(a) upper ground water occuring in the confining layer closest to the surface. This water is subject to intensive climatic influence and reflects its annual variation, which makes this type of river feeding relatively unstable;

(b) deep, ground water, i.e. water free from head or with local head, occuring below the first aquiclude, at the local base levels or above them. The regime of flow of this type of water into streams is usually determined by long-term cycles of climatic effect on the accumulations and regime of ground water, conforming to which is the stability of variations of its supplies.

Of lesser importance in river feeding are temporary accumulations of ground water in the aeration zone, such as temporary perched water, subsoil water as well as water in the zone of delayed flow encountered as deep artesian-type water.

Thus, the regime of base flow varies with the character of ground occurrence. The proportions of different varieties of ground water flow in the feeding of rivers also vary with territory in accordance with the changing geographical zones.

In establishing a division of the European part of the U.S.S.R. into regions according to the conditions of ground water flow into rivers, M.P. Raspopov determined four latitudinal zones differing as to character of drainage, viz:

(1) zone of predominant drainage by rivers of upper ground water, comprising geographical zones of tundra and forest (northern part), marked by conditions of excessive moisture supply;

(2) zone of abundant drainage of upper and deep ground water, coinciding with the subzone of southern forests and partially with the forest-steppe zone, marked by conditions of sufficient and unstable moisture supply;

(3) zone of drainage of predominantly deep ground water roughly coinciding with the steppe zone and marked by conditions of unstable and insufficient moisture supply;

(4) zone of impeded ground water flow, coinciding with the zone of extreme aridity (semidesert), where with ground water occuring at a great depth and with a scarcity of river valleys the subsurface flow into streams is usually excluded.

A.M. Norvatov (1950), who investigated conditions of minimum flow formation in connection with base flow, has developed a principal scheme of divisional distribution of minimum flow values for small rivers by defining regions characterized by the same type of conditions of flow formation.

In analysing conditions of minimum flow formation, and proceeding from the assumption that in accordance with the principal laws of the conditions of formation of dynamic supplies of ground water, the rate of stream-flow in low water periods genetically connected with the latter in its distribution over the territory, likewise obeys the law of geographical zonality.

The character of variations of minimum flow values under the influence of latitudinal geographical zonality may be judged by comparing the tabulated mean values of minimum daily flow in summer for latitudinal geographical zones in the plain territory of the European part of the U.S.S.R. (Table 1).

TABLE 1

Distribution of Mean Daily Rates of Minimum Flow in Summer for Various River Basin Areas (After A.M. Norvatov)

Geographical zone	Geographical latitude*	*Discharge in sec/1 per km² for basin areas of sq.km.* 5000	3000	1000	Note
Zone of tundra and forest zone (taiga)	62-58°	2.7-1.0	2.0-0.7	0.9-0.4	Corresponds predominantly to drainage of upper ground water.
Forest zone (mixed forest)	58-54°	1.0-0.5	0.7-0.4	0.4-0.2	Corresponds to zone of upper and deep ground water drainage
Steppe zone	54-50°	0.5-0.2	0.4-0.2	0.2-0.0	Corresponds to zone of drainage of predominantly deep ground water
Semi-desert zone	50-46°	0.2-0.0	0.1-0.0	0.0..	Corresponds to zone of impeded flow into streams

* at 50° E.L.

As the same time the rate of stream-flow in low water periods, i.e. the mean value of the minimum flow expressed by a specific index (discharge in sec/1 per km²), within a geographical drainage zone varies for various particular regions under the influence of regional and azonal conditions.

Intrazonal deviations of the rate of stream-flow in low water periods from its zonal-geographical value are primarily determined by:

(a) peculiarities of aquifers and underground water accumulations (supplies, thickness and water-yield of layers) determined by regional hydrological conditions;

(b) draining capacity of the river which is determined by the depth of the river-bed erosion cut and the height of ground water accumulations in relation to the sites of discharge (river bed), which is connected with the geomorphological conditions of the territory.

Moreover, the rate of minimum flow for some water bodies may be substantially affected by local factors, such as the regulating influence of lakes, egress of deep ground water, Karst phenomena, etc., which cannot always be taken into account quantitatively due to the shortage of data concerning them.

With qualitative uniformity of the territory as regards hydrogeological conditions and water supply provided by ground water, quantitative differences in the rate of minimum flow of various rivers are determined by one of the most important elements of the draining capacity of a river, i.e. the depth of the erosion cut of its valley. The established relationship between the rate of minimum stream flow and the depth of the erosion cut, as determined by the actual data of specific regions (forest-steppe and forest zones of the European part of the U.S.S.R.), manifests itself in the fact that within relatively uniform hydrological regions minimum discharge in second-litre per square kilometre increases in proportion to the depht of the erosion cut (Fig.1). Such a relationship is valid only for a certain range of river basin areas (small rivers) which is not to be regarded as the same for all regions.

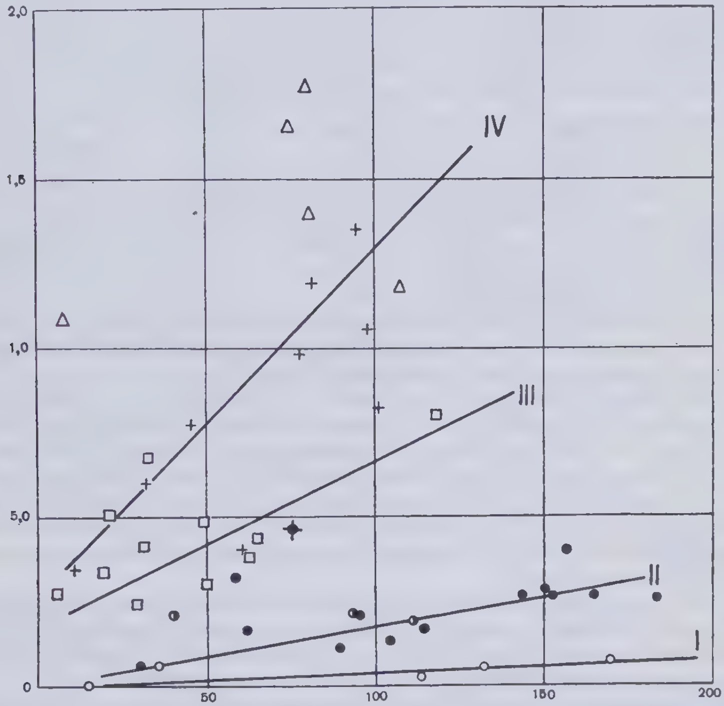

Fig. 1 — Relationship between mean minimum monthly discharge in sec/l par km^2 and depth of erosion cut in various hydrogeological conditions.
I — Quaternary deposits,
II — Sands and sandstones of paleogene,
III — cretaceous deposits,
IV — limestones of Devon.
Triangle indicates karst.

The depth of an erosion cut is a value difficult to determine. For practical purposes, therefore, it may be replaced by an indirect index, i.e. drainage basin area. This quantitative index was adopted as one of the principal criteria in determining the boundaries of regions within which the conditions of formation of minimum flow for the territory are qualitatively uniform. In the meantime, relationship between river basin areas and flow rates proved to be

different for different regions, a change in this relationships corresponding to one in the conditions of flow.

Particular recommendations developed in the U.S.S.R. for determining minimum flow rates for rivers with no stream-flow data available are based on arguments which more or less reflect natural laws.

The effect of geographical zonality is clearly proved by maps of isolines of minimum daily and monthly discharge in second-litre per square kilometre compiled for the European part of the U.S.S.R. (V.A. Uryvaev, 1941; L.N. Popov, 1952) which distinctly reflect the regular decrease of discharge from the norh southwards.

The existing empirical design formulas (M.E. Shevelev, 1937; N.D. Antonov, 1941) in the general form of $q_{min} - f(M_0F)$ (where q_{min} is the minimum discharge in second-litre per square kilometre; M_0 is the mean annual discharge in second-litre per square kilometre; F is the drainage basin area) include as a principal parameter the value of mean annual discharge of rivers in second-litre per square kilometre whose distribution over the territory obeys the law of geographic zonality. Parameter F to a certain extent reflects the draining capacity of rivers.

The role of geographical zonality is also taken into account in the map of base flow coefficients compiled by B.V. Poliakov (1947) who used a coefficient $K = \frac{q_{min}}{M_0}$ in establishing a regional division of base flow.

In recent years the State Hydrological Institute has continued with research concerning the genetic characteristics of minimum stream-flow.

On the basis of summarizing extensive material from many years of observations (770 stations) regional division has been completed for the European part of the U.S.S.R. as regards conditions for the formation of minimum flow.

Practical recommendations have been worked out for determining the rate of minimum flow for rivers, with no stream-flow data available, based on using laws of minimum flow formation in connection with base flow (A.M. Norvatov, 1956).

In identifying regions uniform as to conditions of the formation of minimum flow, account was taken of the extent of community of geomorphological and hydrogeological conditions as well as the simple relationship (within the region) between minimum discharge in second-litre per square kilometre and river basin area assumed as an indirect index of the erosion cut. On the basis of this principle 27 hydrological regions have been identified on the territory of the European part of the U.S.S.R. within which rates of minimum discharge in sec/l per km² have been established for rivers with no stream-flow data available, with drainage basins ranging from 200 to 1000 sq. km (Fig. 2).

Utilizing the principal methods developed in the State Hydrological Institute, the above-mentioned scheme of regional division has been rendered more specific by the Institute of Hydrology and Hydrotechnics of the Academy of Sciences of the Ukrainian S.S.R. for application to the territory of the Ukrainian S.S.R. (K.A. Lysenko, 1959).

The State Hydrological Institute has developed principal methods for basic long-range forecasting of the rate of stream-flow in low-water periods for vast territories (A.M. Norvatov, 1958).

Taking into account the laws of minimum flow formation associated with base flow, it proved to be possible to outline, with the example of the forest-steppe zone of the U.S.S.R., a basic scheme of forecasting the rate of stream-flow a long time in advance (3 to 5 months).

Keeping in mind that the extent of base flow in low-water periods largely depends on the supply of ground water accumulated in river basins in the previous period, use was made of the characteristic of ground water depletion which manifests itself in the fact that the latter possesses great inertia and, therefore, the discharge of ground water into rivers is a long process. Assumed as an index of the previous supply of ground water was a derivative value of ground water flow: discharge in the winter period expressed by minimum discharge in second-litre per square kilometre, this value being the principal forecasting argument. The effect of spring flood

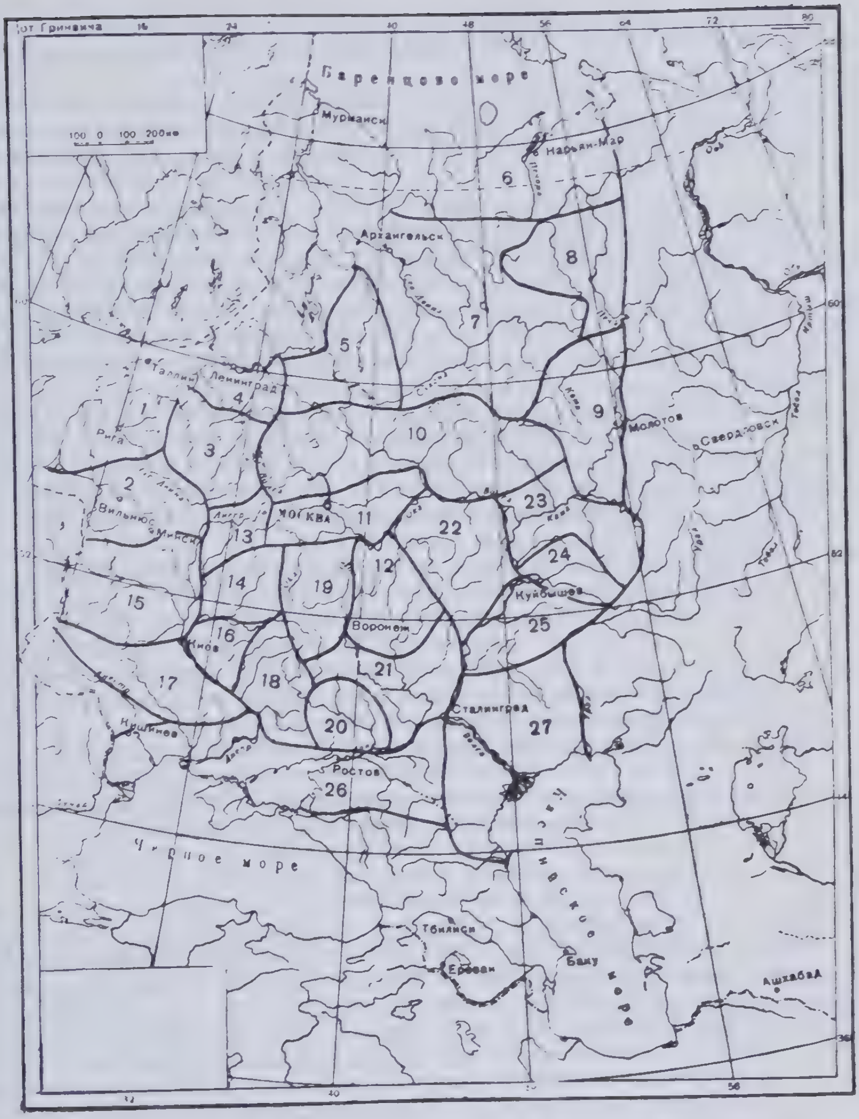

Fig. 2 — Schematic map of regions of similar conditions of minimum flow formation.

and summer rains on the change in underground water resources was taken into account by methods of synoptic meteorology.

Closely linked with the problem of minimum stream-flow formation are the phenomena of drying up and freezing through of rivers, these phenomena being determined by the depletion of ground water, the principal source of river feeding in low-water periods.

The possibility of drying up and freezing through of a river is connected with the charact of ground water resources (water yield, depth of water table) and the draining capacity of th river determined by the position of the erosion cut in relation to aquifers and ground wat accumulations.

In the winter season low temperatures promote the freezing of soil thus accelerating th process of depletion of ground water resources as part of them passes into the solid stat The compiled map of geographical distribution of the phenomena of drying up and freezin through of rivers in the USSR (A.M. Norvatov, 1950) shows that the distribution of these phe nomena over the territory reflects geographical zonality; the intensity and clearness of the pro cesses leading to the disappearance of channel flow in a stream are likewise connected wi drainage basin areas which indirectly characterize the depth of erosion cut.

Further development of methods for computation and forecasting of low flow shou proceed on the basis of complete genetic analysis of low flow formation with due regard fo the effect produced on it by the regional and azonal conditions of particular regions. This particulary essential in the case of human activities changing local conditions (afforestatio tillage, irrigation, etc.).

In determining these intrazonal deviations in low-flow formation it is of great importan that account should be taken of the local peculiarities of ground water feeding, this being on of the most dynamic decisive factors. The study of the peculiarities of ground water feedin should be based on establishing the physical laws of the movement of water in soils unde natural conditions in drainage basins, primarily as dependent on the hydraulic and physic properties of soils in the aeration zone.

Theoretical and experimental studies as well as field observations conducted in this re pect, with Soviet Scientists (A.F. Lebedev, 1936; G.N. Vysotzky, 1933; A.A. Rode, 195 1956; and others) making an important contribution, render it possible to plan the ways o obtaining summarized quantitative characteristics of ground water feeding under natur conditions on drainage basins with regard for the humidity regime of the aeration zon

The prevailing form of ground water feeding in the territory of the U.S.S.R. is the perco lation of rain water and snow melt through the areation zone* (see page 11).

A particular case of ground water feeding is the movement of a capillarily saturate infiltrating flow which on the basis of Darcy's law is most completely described in G.A. Alexeev theoretical scheme. This scheme serves as a working hypothesis in field investigations conducte by the State Hydrological Institute (1948) on infiltration losses of runoff.

As shown by the theoretical works of S.F. Averianov (1949) and other authors, the coeffi cient of filtration is a linear and continuous function of the humidity of the soil. This justifie the assumption that the flow of water caused by the force of gravity and contributing to groun water feeding, under the conditions of constant but incomplete saturation of the moist laye is also closely described by Darcy's law. In the case of an established constant expenditure o water for ground water feeding, of interest of the quantitative evaluation of the flow is th experimentally determined relationship between the humidity of the moist layer of the aeratio zone and the discharge of the flow (S.M. Proskournikov, 1948). In conformity with the rate o flow a strictly definite rate of humidity of soil prevails in the aeration zone above the groun water table, which offers a possibility of quantitative evaluation of ground water feeding on large section of a drainage basin on the basis of analysing the humidity regime of the aeratio zone by experimental data (O.V. Popov, 1956).

Relationship between the humidity of soil and percolation discharge finds theoretical justi fication for studying water movement at a very low soil humidity, when the movement proceed under a very complex combined effect of Van der Waal's forces, electric forces, Newton' gravitation forces and the force of gravity (S.V. Nerpin, 1954). In this case a strict mathe

(*) In some areas, of arid regions in particular, the movement of water vapour may play a certai role; its quantitative significance, however, needs to be more precisely ascertained.

tical plotting supported by experimental material, permits, with a certain granulometrical composition and humidity of soil, the calculation of the value of percolation down to the ground water table and to evaluate the rates of its feeding.

In all cases of evaluating underground water feeding, need arises under the definite hydrogeological conditions of a river basin to determine the possibility of calculating the amount of water moving down to the ground water table by means of parameters and coefficients disclosing the effect of certain basic factors which can be defined by an independent experimental method.

Therefore, in studying the characteristics of low-flow formation, as in solving the entire problem of the formation of runoff, the Hydrometeorological Service of the Soviet Union in its hydrological investigations pays special attention to experimental field observations aimed at obtaining quantitative characteristics of percolation in various physiographical conditions with regard for the pecularities of the physics of this process dependent on the humidity of soils and their hydraulic and physical properties.

The complexity of solving these problems under field conditions is due to the fact that in many cases underground water feeding proceeds in a very non-uniform manner on the draining basin's area, and, because of a limited number of observation points on it, it is difficult to obtain summary characteristics even within the limits of small drainage basins.

Under these circumstances the most complete evaluation of the conditions of low-flow formation may be obtained by comprehensive water-budget investigations including hydrogeological observations and employing the method of hydrodynamic analysis of data on ground water levels after G.N. Kamensky (A.V. Lebedev, 1959). In the Soviet Union such investigations are conducted primarily in the regions of great economic importance.

All hydrological studies of the inter-relation of underground and surface water on the wide network of stations of the Hydrometeorological Service are organized and conducted according to a single program (O.V. Popov, 1959).

Integrated investigations of low stream-flow in respect of the geographical zonality of natural phenomena and the physical laws of the processes which determine them, offer vast possibilities for solving the problem of low-flow formation not only in various physiographical zones, but also with regard for the general changes in the rate of flow under the influence of the economic activities of man.

Unlimited prospects lie ahead for solving all the afore-mentioned problems by combined efforts of scientists from the various countries of the world.

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A SEMANTIC REVIEW OF THE TERMINOLOGY OF GROUNDWATER MAPS [1]

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Note de la Rédaction : Monsieur Margat, consulté par le Secrétaire, a bien voulu marquer son accord sur le contenu de la note de Monsieur Meyboom.

In a recent issue of the Bulletin of the International Association of Scientific Hydrology, J. Margat raised a question concerning the terminology to be used to designate the various types of groundwater maps. His article strongly advocates international understanding and it is the first of its kind to suggest English and German equivalents of the terms used in France. The need for international uniformity becomes apparent indeed when one compares articles from different countries dealing with the cartographic representation of groundwater data. This matter of uniformity is of extreme importance, for both the outcome of international scientific co-operation and the degree of mutual understanding depend mainly on the proper translation of ideas into terms that have the same meaning to all who use them; and Margat's attempt must therefore be highly appreciated.

The purpose of this paper is to discuss the semantics of some of the English and German terms suggested by Margat, and to warn of some of the pitfalls related to the translation of scientific terminology.

1. Cartes des eaux souterraines

English : Ground waters map (Margat, 1960)
German : Grundwasserkarte (Margat, 1960)

First of all it should be noted that in the English language compound words used as adjectives immediately preceding nouns which they modify, take a hyphen (G.P.O. Style Manual, 1959). According to this so-called «rule of unit modifiers», the words «ground» and «waters» should be hyphenated, thus becoming : *ground-waters* map. «Ground waters» is a literal translation of «des eaux souterraines», but in common English usage the word «groundwater» (or ground-water) is a pluralia tantum, which means that the singular and plural form are alike. Consequently, the plural «s» of ground-waters should be omitted, giving : *ground-water map*, in which case «ground-water» is a compound adjective modifying «map».

The word *groundwater* is composed of the nouns «ground» and «water» and when these two nouns first were used in this particular combination to indicate a special kind of water, they were doubtless written separately. However, the fluidity of living language tends to close up such compound words which through frequent use have become units of thought (G.P.O. Style Manual, 1959, p. 69). During this process of unification the words pass through the following stages :

1. The words are still separate (ground water; water year)
2. The words are hyphenated (ground-water; water-level)
3. The two words become one word (groundwater; watershed).

It is interesting to recognize these various stages of word evolution among contemporaneous American authors. Examples :

Ground water : (Mann, 1957);
Ground-water : (Ferris and Sayre, 1946; Schneider, 1957);
Groundwater : (Bergstrom and Selkregg, 1957).

[1] Research Council of Alberta, Contribution 139.

Judging from this trend in language it seems justified to expect the finally accepted fro to be the single word, which implies that the proper English equivalent of«carte des eau souterraines» has to be *Groundwater map*, as is already the usage in some places in Canad and the U.S.A.

Margat's proposal to retain the term «Groundwater map» in a general sense, indicatin any type of map that presents one or two more groundwater characteristics, seems to be full acceptable.

In discussing general features of German groundwater maps, Grahmann (1958) indee employs the term «*Grundwasserkarte*» which on that account seems to be the proper Germa equivalent. An exception to this rule is the Grundwasserkarte der Bundesrepublik Deutschlan scale 1 : 1 million, which contains specific hydrologic information as well as geologic infor mation.

2. Cartes Hydrogéologiques

English : Hydrogeological maps (Margat, 1960)
German : Hydrogeologische Karten (Margat, 1960).

These terms have been coined to indicate maps that show «la situation géologique de eaux souterraines et caractères géométriques des principales nappes. Une carte hydrogéologiqu doit conserver les élements essentiels d'une carte géologique» (Margat, 1960).

The English term seems certainly acceptable but has not as yet been defined as such i English or American literature. Todd (1959) refers to hydrogeology in a rather general way a «the science of the occurrence, distribution and movement of water below the surface of th earth », a definition which is in accordance with the adjectival usage in the above-mentione term. In recent Russian literature the English term «hydrogeological map» has been used t designate «a variety of a geological map, drawn to characterize subsoil waters running in th rock. Regardless of their scale, all hydrogeological maps give complex characteristics of sub soil waters» (Churinov, 1957). Churinov's definition agrees with that given by Margat and ther appears to be unanimity among authors about the usage of the English term «*Hydrogeologi cal maps*»; therefore, its usage in the sense of Margat should be retained.

The proposed German term «*Hydrogeologische Karten*» has been used by Grahman (1957) to indicate maps that show «the occurrence and nature of water-bearing formations on th basis of general geologic structure». However, as Grahmann points out, in order to be o practical value they must also contain information as to the amount of permanently obtainabl groundwater, which he calls «geohydrological information». Consequently, only small-scal regional maps on which hydrogeological data play the more important role are true «Hydro geologische Karten», whereas larger-scale maps, showing smaller areas in more detail and to b used for quantitative-planning purposes, have to be of a more geohydrological nature. This bein the case, it seems that the usage of the German term «Hydrogeologische Karten» is somewha more restricted than the French or English equivalents, as the proper usage of the German terr depends on the scale of the map in question.

3. Carte de ressources en eau souterraine

English : Occurence of ground waters maps (Margat, 1960)
German : Grundwasservorkommen Karten (Margat, 1960)

Margat proposed the term «Carte de ressources en eau souterraine» to designate two bas cally different types of maps, which, however, both show specific quantitative information re lating to the practical availability of groundwater. As is explained below, this differentiatio serves a very useful purpose, and it reflects to what highly different stages groundwater studie have progressed in various countries.

The English term proposed to cover both types of maps is neither semantically nor idiomatically satisfactory. Semantically the term means at the most «the *occurrence* of *groundwater maps*», which is not meant by Margat. It is sufficient to refer to the previously mentioned «rule of unit modifier» in bringing forward that all words preceding the word «maps» should have been hyphenated. This would produce a rather awkward adjective which does not lend itself to a convenient abbreviation that may sometimes solve such a problem. (Example: SAR diagram for Sodium-adsorption-ratio diagram.) It seems preferable to suggest the English term «*Groundwater-resources*» map as equivalent of the French term «Carte de ressources en eau souterraine».

As for the German term, there already exist two other names to indicate maps of such quantitative nature:

a) *Hydrogeologische Ubersichtskarte* (1 : 500,000), which according to Grahmann (1954) is required to contain information concerning the relation between groundwater resources and geology of the aquifers, the amount of natural recharge and present and potential utilization of the groundwater resources. All of Western Germany will eventually be covered by such map-sheets.

b) *Hydrogeologische Spezialkarte* (1 : 25,000), a term introduced by Matthes and Thews (1959) to indicate large-scale maps also combining geological and hydrological data. Such maps furnish information as to the amount of natural groundwater discharge, available quantities of groundwater, location and extent of intake areas, source areas and areas of potential large-scale groundwater withdrawal.

Although these map differ in scale, their contents are in accordance with Margat's definition and both terms are therefore synonymous with «Carte de ressources en eau souterraine», making the term «Grundwasservorkommen Karten» redundant.

Among groundwater-resources maps, Margat distinguishes two essentially different types of maps:

a) Carte d'exploitabilité

English: Drawing from ground water possibilities maps (Margat, 1960)
German: Verfügbaren Grundwassermengen Karten (Margat, 1960)

This type of map purports to show the quantity of groundwater that can be withdrawn instantaneously at any given point in the aquifer, regardless of the effects that such withdrawal may have upon the groundwater balance. This amount is determined by the thickness and the permeability of the aquifer, or in other words, by the transmissibility (Margat, 1960).

Before suggesting an English equivalent for the French term «Carte d'exploitabilité», it is necessary to explain briefly some rules related to translation in general and particularly to the translation of scientific terms.

As has been pointed out by Wiener (1956) the imperfect correspondence between the meaning of words restricts the flow of information from one language into another. Each language has its own precise distinctions and the meaning of a literal translation is not necessarily the semantic image of the original text. Consequently a certain amount of information is lost during translation, never to be regained. This tendency of deterioration of information has been called the *cybernetic form of increasing entropy* (Wiener, 1956). Even if only a small amount of information dissipates during translation, slight semantic shifts result, causing serious misunderstanding. For instance, the official Dutch translation of the term «watershed» covers only the geomorphological divide between two drainage basins (Schieferdecker, 1959) in contrast to the wider American usage which implies a «small drainage basin» (Langbein and Hoyt, 1959). As increasing entropy tends toward total disorganization, the final product of successive (literal) translations can be expected to become semantically senseless although it still may bear some phonetic relationship to a particular language.

Increasing entropy during translation is best illustrated by re-translating the translated text back into the original language. This process of re-inserting into a system the results of

its past performance is referred to as *feedback*. Feedback can thus be used to measure th amount of information dissipated during translation, simply by determining the degree o semantic correspondence between the original text and the returned one.

The translation of scientific terms should be directed primarily toward full preservatio of semantic correspondence, which means that, as a rule, literal translations are undesirabl for the fine semantic shades of scientific terms are likely to be lost during translation. Marga most certainly realized this problem, for his suggested English and German equivalents of th original French terminolgy are seldom literal translations. Nevertheless, the information co veyed by the French expression «carte d'exploitabilité» is completely lost in the propose English equivalent «Drawing from ground water possibilities map». This is best illustrate by re-translating the English term into the French language, giving:

«Le dessin des cartes des eaux possibles souterraines», or

«Le dessin des possibilités des cartes des eaux souterraines».

These phrases show that increasing cybernetic entropy during two stages of translatio is sufficient to cause total semantic disorganization. An English-speaking geologist trying translate his ideas into French terminology would encounter exactly the same problems, fo most idiomatic scientific expressions do not lend themselves to direct translation but requi bilingual understanding of the science itself. It is obvious from the above considerations th the term «Drawing from ground water possibilities map» should be rejected in favor of a mo suitable term.

The type of quantitative groundwater map that Margat wishes to distinguish certain is known from English or American literature. Bergstrom and Selkregg (1957) described suc maps of the State of Illinois, on which the probability of encountering certain types of aquife is shown by means of a special symbol, and Christiansen (1960) presented a groundwater ma of the Qu'Appelle area in Saskatchewan (Canada), indicating the probability of findir certain quantities of water at any given location. Keech and Dreeszen (1959) compiled a groun water map of Clay County in the State of Nebraska, based on transmissibility values, whi De Ridder and Hondius (1958) constructed similar maps, showing Kd values of various aquife in the northern part of Limburg (Netherlands). As has already been mentioned by Margat (1960 transmissibility values determine the amount of groundwater that is available for immedia use, and maps like those presented by Keech and Dreeszen or De Ridder and Hondius, shoul therefore be called *Transmissibility maps*. In cases where the transmissibility values are tran lated into terms of «good, intermediate, and poor» water-yielding areas, the maps general show the probability of encountering specific amounts of groundwater by means of speci symbols. Such maps are called *Groundwater-probability* maps. It should be kept in mind th the word «probability» is in this case not used in a mathematical sense, for such maps are n constructed on the basis of a formal mathematical model. The probability referred to on the maps is therefore not the ratio of the number of favorable cases to the whole number of cas possible, but merely the likelihood that a certain expectation will prove to be true.

The suggested German term «Verfügbaren Grundwassermengen Karte» seems have a predecessor in the German literature where both Nöring (1957) and Grahmann (195 used the term *Grundwasserhöffigkeit Karte*, to specify maps showing the degree of probabili that certain groundwater resources can be exploited (Grahmann, 1958, p. 33). The retentic of the usage of this original German term is therefore recommended rather than the introductic of a less appropriate expression.

b) Carte des ressources en eau souterraine

English: Occurrence of groundwater- or ground water disponibilities map (Margat, 196
German: Grundwasservorkommen Karte (Margat, 1960)

It is regrettable that Margat coined this term either in a general sense or with a mo restricted meaning. In its restricted meaning the term denotes those groundwater maps th show long-term yield or, in other words, maps showing the amount of groundwater withdraw

that can be maintained without depleting the aquifer. Such maps are the cartographic presentation of the entire groundwater balance, for they show the combined results of interaction between geology, climatology and hydrology. Maps of this type have great significance for planning purposes where the knowledge of long-term groundwater yield can be of utmost importance.

This distinction between maps showing long-term yield and those showing instantaneous yield demonstrates the highly advanced state of groundwater studies in France as well as in some other countries. Obviously the need for such highly specialized groundwater maps has not as yet presented itself in one of the English- of American-speaking countries, for descriptions of such maps are conspicuous by their absence in American of English literature. However, the first English term proposed by Margat is difficult to accept as it is not sufficiently specific with regard to the type of map it indicates, and the alternative term is unacceptable as Margat failed to translate the French word «disponibilité» into its English equivalent «availability».

In a recent Russian paper (Kudelin, 1957) the author used the term «Map of underground discharge» in referring to natural groundwater discharge as computed from baseflow analysis. The various maps presented by Kudelin most certainly meet the requirements of the type of groundwater maps discussed by Margat but the term «underground discharge» is incomplete as it does not include groundwater discharge from surface springs. The term is probably the translated version of a much better Russian word, in which case it offers another example of dissipation of information during translation.

By analogy to the proper German term introduction of the term *Groundwater-discharge map* is suggested, which is a map showing the amount of natural groundwater discharge expressed in volume per time area, or in height of water over the entire groundwater-drainage basin. This amount may be computed from stream hydrographs or by any other means, as long as it charactierizes the groundwater balance. The German term suggested by Margat has to be rejected on account of the wide usage of the original German term *Grundwasserspende Karte* (a.o. Matthes and Thews. 1959) which denotes groundwater maps showing natural groundwater discharge expressed in 1/sec.km².

4. Cartes hydrochimiques

English: Hydrochemical maps (Margat, 1960)
German: Chemische Grundwasser Karten (Margat, 1960)

Margat proposes «Cartes hydrochimiques» as a general name for maps showing the chemical composition of groundwater, either in terms of total dissolved solids or in terms of the concentration of dominant ions.

Hem (1959, p.194) refers to such maps as «quality-of-water maps» by which he understands maps that are prepared «by entering numbers or symbols at well or spring locations to represent the concentration of dissolved solids or of individual constituents». In this context the word «quality» is being used in its original meaning of «how constituted», regardless of the practical implications that this composition may have. Hem's terminolgy agrees with Margat's definition and hence on grounds of priority should deserve preference over the term «Hydrochemical maps», but Hem's term is considered unsuitable in the light of further discussion below.

The German term suggested by Margat seems semantically somewhat incorrect as the adjective «chemische» refers to «Grundwasser» rather than to «Karte». Moreover it appears from the literature that the proper general term is «*Grundwasserchemische Karte*» (Nöring, 1957), which term should therefore be retained.

For practical purposes Margat distinguishes two kinds of chemical maps:

a) Cartes hydrochimiques spécifiques

English: not given
German: not given

Margat's conception of such maps is that they show some characteristic chemical component such as hardness or alkalinity. In American literature such maps have not been given special names but their purpose is generally described in the map-title, such as: «Map of..... showing areal distibution of groundwater hardness», or «Map of..... showing alkalinity of groundwater». At present it seems unnecessary to establish a specific English terminology for such maps.

The author is also not aware of the existence of any particular German term.

German groundwater-resources maps 1 : 500,000 include characteristic groundwater by means of certain symbols, making special maps redundant.

b) Cartes de potabilité

English: not given
German: not given

Certain maps showing the chemistry of groundwater may have great practical value by presenting directly the quality of the water in terms of its suitability for human consumption.

	FRENCH	ENGLISH	GERMAN
1.	Carte des eaux souterrraines	Groundwater map	Grundwasserkarte
2.	Carte hydrogéologique	Hydrogeological map	Hydrogeologische Karte
3.	Carte de ressources en eau souterraine	Groundwater-resources map	Hydrogeologische Ubersichtskarte Hydrogeologische Spezialkarte
	a. Carte d'exploitabilité	Transmissibility map Groundwater-probability map	Grundwasserhöffigkeit Karte
	b. Carte de ressources en eau souterraine	Groundwater-discharge map	Grundwasserspende Karte
4.	Carte hydrochimique	Groundwater-composition map	Grundwasserchemische Karte
	a. Carte hydrochimique spécifique	no equivalent	no equivalent
	b. Carte de potabilité Carte d'utilisabilité pour l'irrigation	Groundwater-quality map idem	Grundwasserbeschaffenheit Karte idem

;ation or industrial purposes. In cases where maps are to show the water quality in terms s suitability for irrigation, Margat proposes the term «cartes d'utilisabilité pour l'irrigation». need for differentiation among such groundwater maps again illustrates the advanced that groundwater studies have reached in some countries.

According to Hem (1959) the subject of quality of water as related to use is part of the *rpretation* of quality-of-water maps rather than the subject of a special map. It is the author's nion that the meaning of the term «quality-of-water map» is the best possible equivalent «carte de potabilité», for the word «quality» has strong semantic connotations with destion of conditions of goods to be used for human consumption. Therefore it could be sugges- to reserve the term «quality-of-water map» for maps that show directly the suitability of undwater for human consumption or other purposes. However for the sake of uniformity in order to avoid confusion the term *Groundwater quality map* is proposed as the English ivalent of «Carte de potabilité».

The term *Groundwater-composition* map is suggested to replace the expression «quality-vater map» in the sense of Hem (1959), and to be the equivalent of «Carte hydrochimique». his proposed term the word «composition» has its common meaning of: «the nature of a npound or mixture as regards to the kind and amounts of its constituents» (Webster).

In Germany as well as in France the need exists to differentiate among groundwater maps l Nöthlich (1957) presented a method to show by means of percentages the quality of grounder expressed in terms of its suitability for human use. Such a map is called *Grundwasserchaffenheit Karte* and this name covers both French terms «Carte de potabilité» and «Carte tilisabilité pour l'irrigation».

The preceding paragraphs are summarized in the accompanying table.

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HE UTILIZATION OF RIVER WATER RESOURCES IN ARID ZONES

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1. The present report considers the vast arid steppe territories of the south of the USSR. ese are regions with cold, steady winters and hot, dry summers. The run-off proceeds mainly spring owing to the snow melting. During the rest of the year the river flow is scanty.

2. The mean flow of the rivers in relation to their catchment areas is low and varies greatly m year to year. The average depth of annual flow is 1-2 cm; the coefficient of variation is se to 1.
About 90 % of the water passes during 1-2 spring months. The rate of evaporation in sum- r is high, the precipitation being low. The average annual depth of evaporation losses from water surface of storage reservoirs is approximately 1 m.

3. The flow of the rivers being highly variable, long term records are required to secure curate estimation of the water resources. Systematic flow gauging should be started possibly ng before the beginning of hydraulic works.
Statistical estimation corroborates these considerations. Owing to the high variability the river flow within the arid territories a record of 100 years is required to secure the timation of the mean flow with the standard error $\pm$ 10% ; a 200 - year record is necessary reach the same accuracy in estimating the flow of the 99 % dry year. The correlation between e flow of adjacent years makes the estimation of the river flow statistics still more difficult.

4. The annual flow of dry years is very low. To store the superfluous flow of the wet years the only way to reach a high rate of utilization of the available resources and to secure stable pply even if a lingering drought occurs. Accordingly, long term annual storage becomes the imary means of water resources utilization in arid zones. Water resources limit the economic velopment here; the completeness of their utilization becomes a factor of great importance.

5. The amount of storage required depends on the length and the severity of dryness sequences of deficient years. Only a few samples of their possible combinations are repre- nted by even the most protracted flow records. These samples do not suffice to estimate curately the severity and occurrence of droughts to be expected and the amount of storage cessary to regulate the flow. This problem may be solved only in a theoretical way by estimating e probabilities of different annual flow sequences. Such an approach is closely related with e Markov chain conception. The main interrelations appropriate to this conception are given the report «On the regularities of river flow fluctuations and the methods of estimation of ngering droughts».
Probability methods of storage estimation have been evolved and become widespread. he procedure is based on the composition of frequency distributions of the flow and stored ater. Two ways of solving the problem have been proposed. (To simplify the analysis we eli- inate-provisionally-the seasonal fluctuations of the river flow; thus only the variations of nnual flow are discussed).

6. The first approach to the problem is to study the years and their sequences assumi the reservoir either completely full or empty at the beginning. Let k be the annual flow of t river, and α the annual yield to be supplied, (losses included), both in terms of the mean annu flow. If $k > \alpha$ the supply can be maintained uninterruptedly even with the reservoir emp in the beginning. If $k < \alpha - \beta$ (β — the amount of storage in terms of the mean annual flow shortage of yield is inevitable even with the reservoir full in the beginning. To ascertain the re men of years with the flow $\alpha > K > \alpha - \beta$, such an interval has to be examined jointly wi the preceeding years. The flow frequency distribution is to be composed of the two-year seque ces ended by a year of the specified uncertain interval. Further the same procedure is to be a plied to the sequences of 3.4 ...n years, until the probability of the interval $n\alpha > \sum^{n} K > n\alpha$ — becomes negligible. Thus all annual flows become distributed within two groups: the secured su ply years and the shortage years and the probability of each group is determined. The compo tion can be carried out grapho-analytically [1] or by means of calculating the parameters of t n-year flow frequency distributions [2]. The latter gives the opportunity to take approximate into account the correlation between the flow of adjacent years.

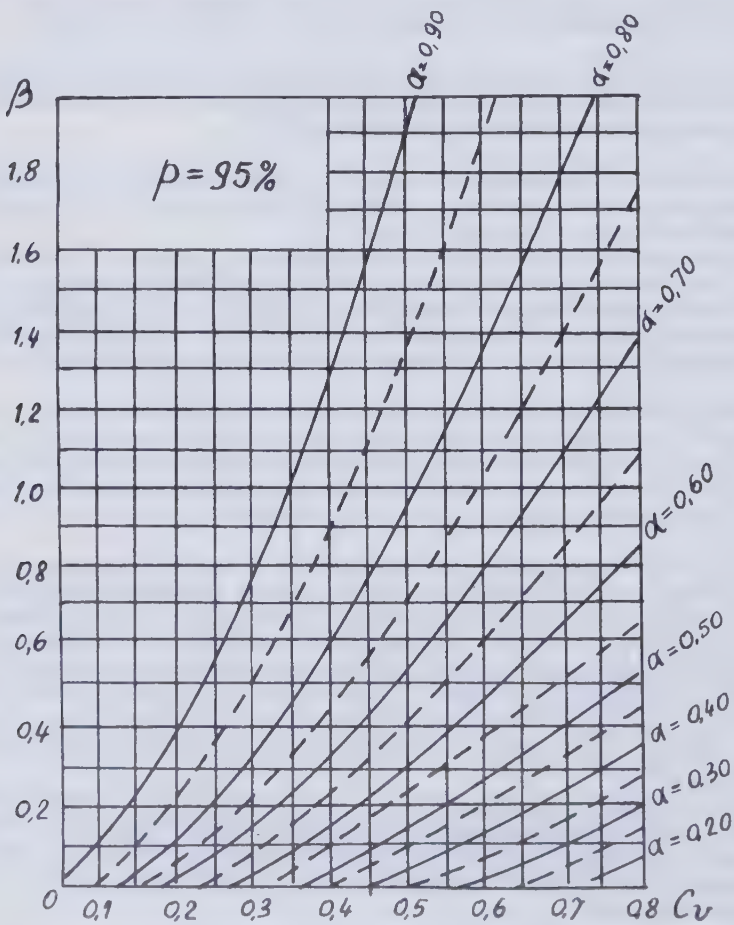
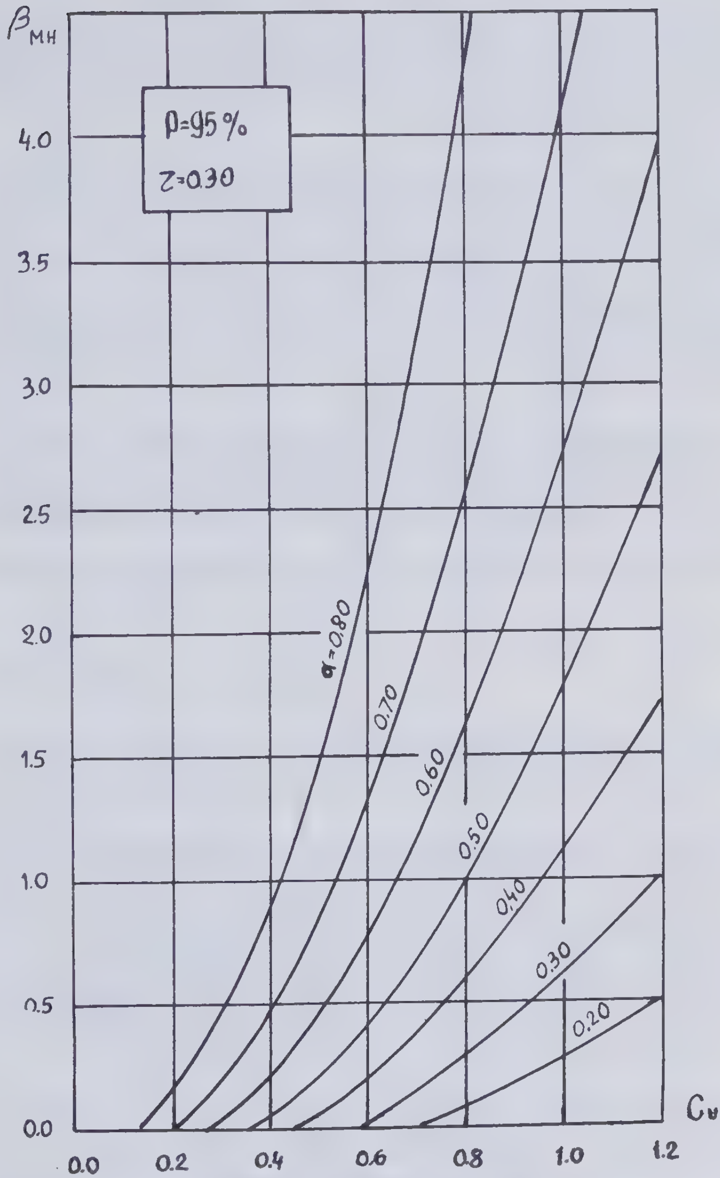


Fig. 1 Annual storage-draft-coefficient of variation of annual flow, 95 per cent of years of secur yield; variation of annual flow supposed independent.



ig. 2 — Annual storage-draft-coefficient of variation of annual flow; (95 per cent of years of secured yield; correlated annual flow with the coefficient of correlation 0.3).

The second approach to the problem consists in succesive—year after year— composition f frequency distributions of the stored water. The initial stage of the reservoir can be presupposed arbitrarily—full or emty—or characterised by a frequency distribution. With the course

of time the frequency distribution of the amount of stored water tends to a stable form indepen-dent of the initial conditions. The composition can be carried out grapho-analytically ([1]) The coordinates of the stable frequency distribution of the volumes of stored water can be calculated also by means of a system of equations. Recently a method has been outlined allowing for introducing into these equations the correlation between the flow values of adjacent years ([3]) In that case the equation become quadratic.

8. By means of the above-mentioned methods graphs have been constructed to correlate the storage and the yield to the variation coefficient of the annual flow and the percentage of years of secured yield. Such graphs are given in figures 1, 2 for 95 % of years of secured supply Figure 1 corresponds to statistically independent, figure 2 to correlated, annual flow with coeffi-cient of correlation between the flow in adjacent years 0.30.

The annual flow coefficients of variation are plotted as abscissae, the required long-term «annual» storage as ordinates. The curves on the graphs correspond to different values of yield expressed, like the storage, in terms of the mean annual flow. The yield α includes evaporation and seepage losses of water.

9. Methods have also been evolved for ascertaining the seasonal component of required storage and for integrated studies of storage capacity necessary to regulate both long-term and seasonal variations of flow. In the case of high long-term flow regulation the «annual» and the «seasonal» components of the storage capacity may be calculated separately and sum-med.

If necessary more accurate methods may be used evaluating the total required storage

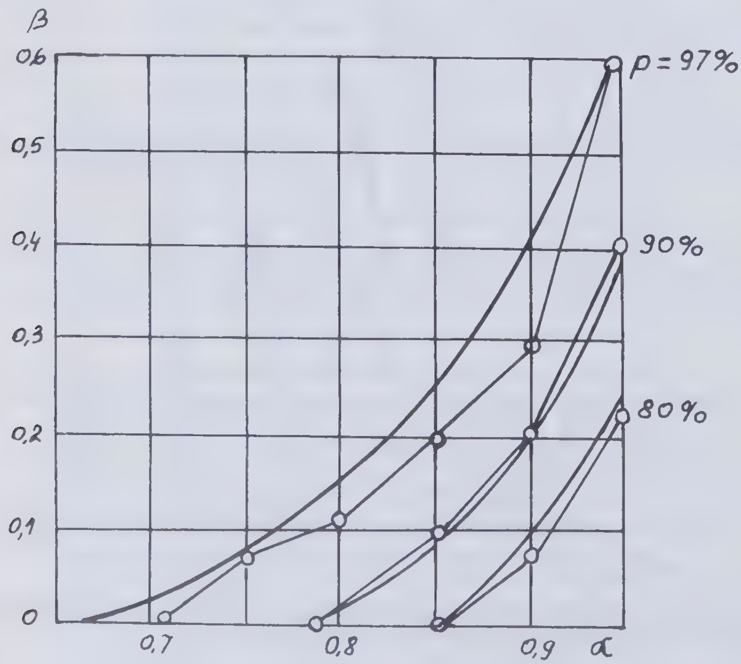
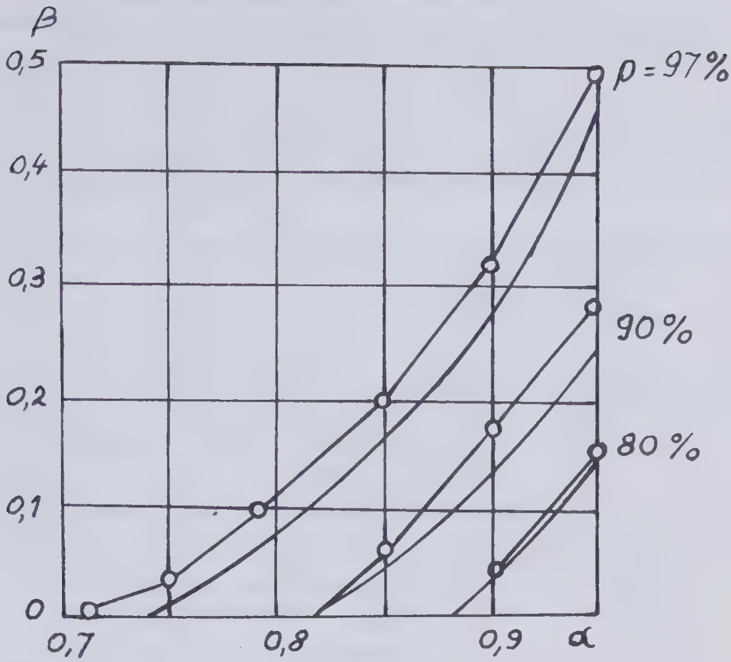


Fig. 3 — Annual storage in relation to draft and per cent of secured supply years; theoretically esti-mated storage-capacities compared with those derived by direct analysis:
a) Niemen river; 100 years gauging records.



b) Rhine river; 100 years gauging records.

10. Attention must be paid to check the theoretical deductions by testing them with direct observations. For example, in figures 3*a* and 3*b* the theoretically estimated storage capacities are compared with those derived by direct analysis of 100-year flow records for the rivers Niemen and Rhine.

In fig. 4 similar comparison is made with regard to the length of reservoir emptying periods.

The theoretical methods allow for estimating the frequency of rare combinations of flow not observed directly during the recorded periods and their influence on the regimen of storage reservoirs. Various aspects of this regimen become cleared up, among them-the amounts of water not supplied during extremely dry periods, the lenght of reservoir depletion periods, the probability of repeated depletion and shortages in adjacent years etc. For example, fig 5. shows the expected mean deficit in yield in relation to the percentage of years of undiminished supply (1). (Coefficient of variation of annual flow 0.5; correlation between the annual flow in adjacent years not taken in account; about 55 % of the run-off passes during 2 spring months).

11. The run-off in arid regions being highly variable big storage reservoirs are required to regulate the flow. The amount of storage stet several times the volume of the mean annual flow. Factors limiting the extension of reservoirs are to be taken into consideration : the production of initial filling; the augmentation of losses due to the growth of the water surface; the high concentration of diluted salts in the water of reservoirs which operate during protracted periods without spilling excessive flow.

12. In arid zones the depth of reservoirs is of great importance. Shallow ponds with little average depth evaporate so much water that the increasing of storage capacity does not augment the yield.

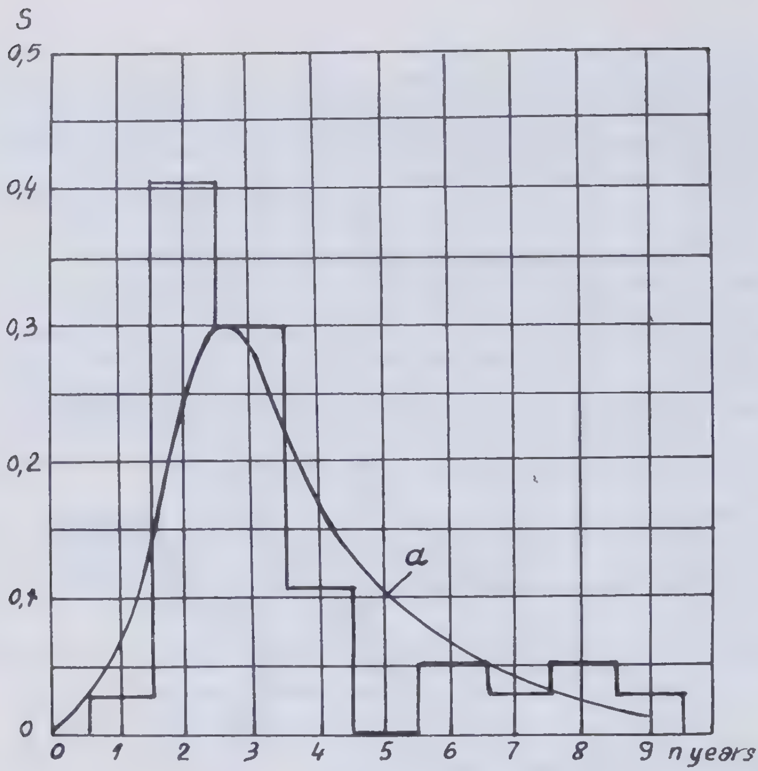


Fig. 4 — Length of reservoir exhausting periods; comparison of theoretical computations with ob-
served data.

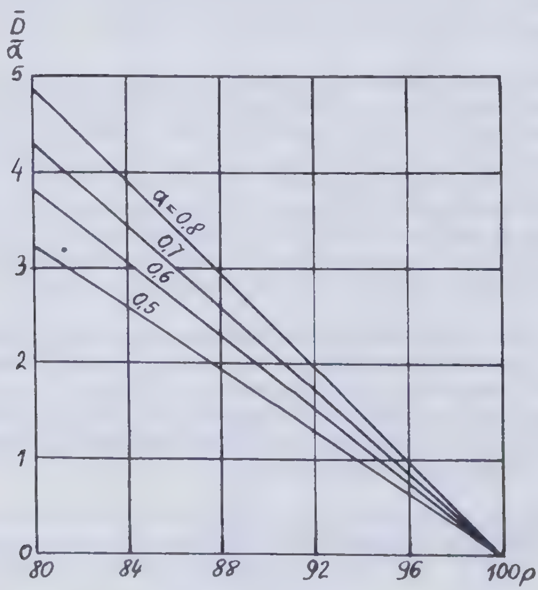
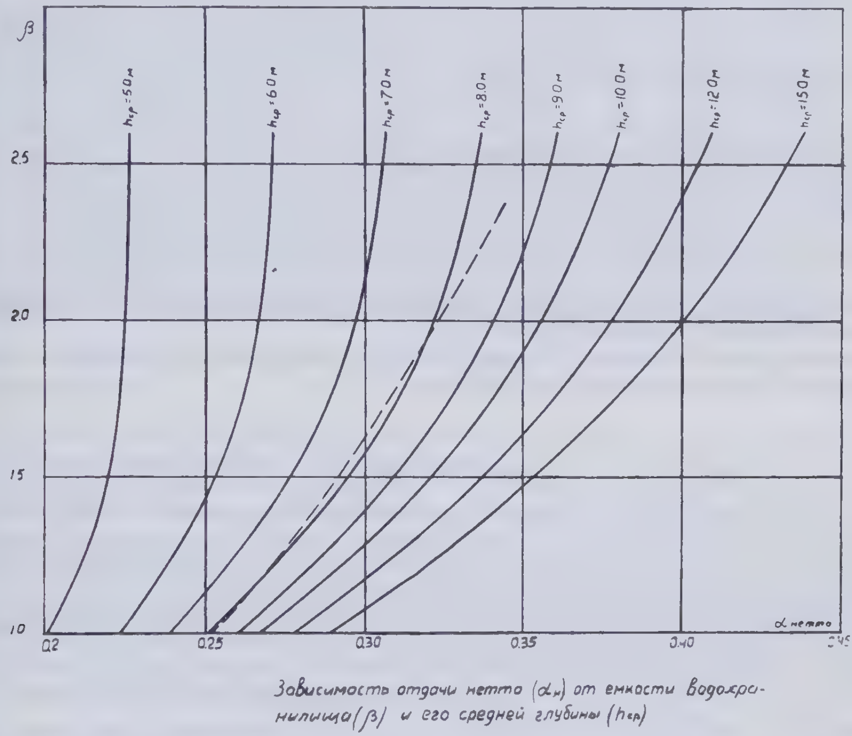


Fig. 5 — Deficit of yield in relation to the amount of yield and per cent of secured supply years
coefficient of variation of annual flow $C_v = 0.5$.

(5) An example illustrating the influence of evaporation—losses on the water-supply is given ı fig. 6 (coefficient of variation of annual flow 1, annual depth of evaporation—losses 1 m). ıe graph presents the net yield (losses subtracted) in relation to the mean depth of reservoir. ıe water supply and the reservoir-capacity are expressed in terms of mean annual flow. the same figure the dotted line shows the relation between the yield and reservoir capacity a real water-supply reservoir. The graph shows that a reservoir with a mean depth of about m. (typical for plain regions) secures the supply of about one third only of the mean annual ɔw; 30 % is wasted with evaporation losses from the water surface and the remaining flow spilled during the rare high floods.



ig. 6 — The net yield in relation to the storage capacity and the mean depth of the reservoir. The coefficient of variation of annual flow $C_v = 1$;95 per cent of years of secured supply.

From what is said it follows that in arid zones it is desirable to concentrate the storage equired to regulate the flow of a river within a few, capacious, deep reservoirs. Numerous small onds are not suggested because of evaporation losses.

13. It seems reasonable to adjust according to the fluctuations of the river flow the water onsumption of industrial and agricultural enterprises located within arid zones. The uninterupted supply of highly important consumers is to be guaranteed in 95-97 % of years. The uxiliary needs may be limited during periods of heavy droughts, the total demands being ontented at full rate, say, in 75 % of years. This pattern allows an enlarged utilization of limited vater resources. During the majority of years the supply will be maintained without shortages. n the case of extraordinary droughts the most vital requirements will be secured safely.

14. The capacious reservoirs storing several volumes of the mean annual flow of the river need long periods for their initial filling. If this process coincides with a protracted drought the initial filling lasts many years. During this period the normal safety of the supply can not be secured.

Probability methods allow the study of the regimen of the water supply during the initial filling of the reservoir. The technique is to examine the flow and the yield year after year assuming the reservoir empty in the beginning. The probabilities are to be calculated of the amounts of water stored at the end of each consecutive year. Some results of such study are illustrated by the following table.

Years after the beginning of the initial filling	1	3	10
Draft (net) in terms of the supply maintained within 95 % of years the initial filling completed	0.1	0.7	1.0

The full capacity of the considered reservoir is 2.5 in terms of the mean annual flow. The depth of annual evaporation losses—1 m.

To prevent delay in the work of supply-dependent enterprises it is necessary to put the construction of reservoirs in hand in good time.

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SEASONAL METEOROLOGICAL EFFECTS UPON STREAMFLOW IN NORTHERN UTAH (*)

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ABSTRACT

A watershed's seasonal streamflow fluctuations are caused by meteorological conditions as they are modified by the watershed's inherent characteristics such as size, shape, aspect, geology, and plant cover. Records from Halfway Creek watershed, a perennial tributary to Farmington Creek located on the Wasatch Mountains in northern Utah, show that winter streamflow comprises only a small portion of the total annual yield. The winter contribution, which is low but constant, originates as drainage from deep aquifers. A much greater portion of the water yield comes in the spring as seepage flow derived from melting snow and spring rains, although the highest instantaneous spring peak so far recorded is only 24 csm (cubic feet per second per square mile). Initial recession of the flow of Halfway Creek from its spring peak is rapid, but in a short time its decrease becomes so gradual that in late summer the hydrograph becomes an almost flat line. The summer recession ends when climatic conditions in the autumn cause cessation of plant growth. Rainstorms often interrupt the normal summer recession. Most of these interruptions are brief, but the height of the peak varies widely. For instance, in the 24-year period 1923-1947 when the vegetation cover was depleted, overland flow from short duration intense summer rainstorms caused mud-rock floods from Halfway Creek watershed that had instantaneous peaks 100 to 200 times greater than the spring peak. The relations presented in this report were determined for a small area and are based on specific records. They apply in a general way to a much greater area in northern Utah and the Intermountain West of which they are representative.

1. Introduction

The flow of water from Halfway Creek on the Davis County Experimental Watershed is typical of many streams draining steeply sloping forest-, brush-, and rangelands of northern Utah and similar areas in the Intermountain West. Discharge records from this perennial stream, a tributary of Farmington Canyon that drains 464 acres, illustrate how seasonal weather conditions can cause great differences in streamflow.

The average annual flow from Halfway Creek is 21.5 area inches. Nearly all of it is seepage. Usually most of it has come in the spring as the winter snows melted, but occasionally (during the 24-year period 1923-1947) a relatively small amount of water from high-intensity summer rainstorms surged into the stream channel as overland flow and caused mud-rock floods having fantastically high peaks. Records and estimates for one of these floods contrast its peak and that of highest snowmelt spring peak thus far recorded.

2. General effect of precipitation upon streamflow

The snowpack on lands above 6,500 ft elevation is the principal source of water for perennial streams in this area. Snow begins accumulating on these high mountain watersheds each year about 1 November, and by 1 April the snowpack usually contains 20 in or more of water (fig. 1). The maximum snow depth to date on the snow course at 8,200 ft elevation in Davis County, 108.4 in in 1952, is twice the minimum, 53.6 in in 1954; and the maximum water content, 41.8 in in 1952, is 2.6 times as great as the minimum, 16.0 in in 1954.

Water from the snowpack, together with that from autumn storms preceding snowpack formation, and that from spring storms during the melting period (although variable from year

(*) Part of the material in this article was presented at the 166th National Annual Meeting of the American Meteorological Society held at Logan, Utah in June 1958.

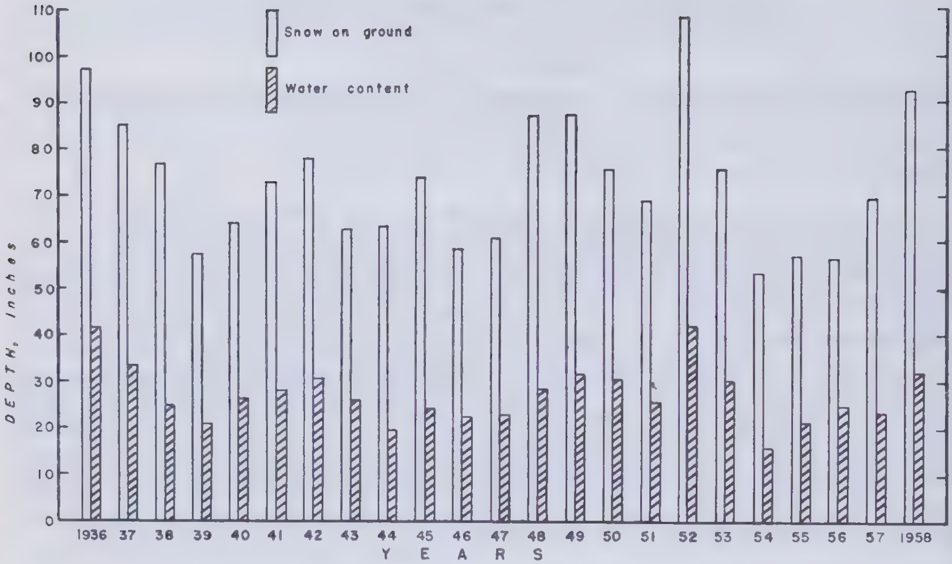

Fig. 1 — Snow depth and water content about 1 April, Barnard Creek snow course, Davis County Experimental Watershed, Utah, 8,200 ft elevation, 1936 to 1958.

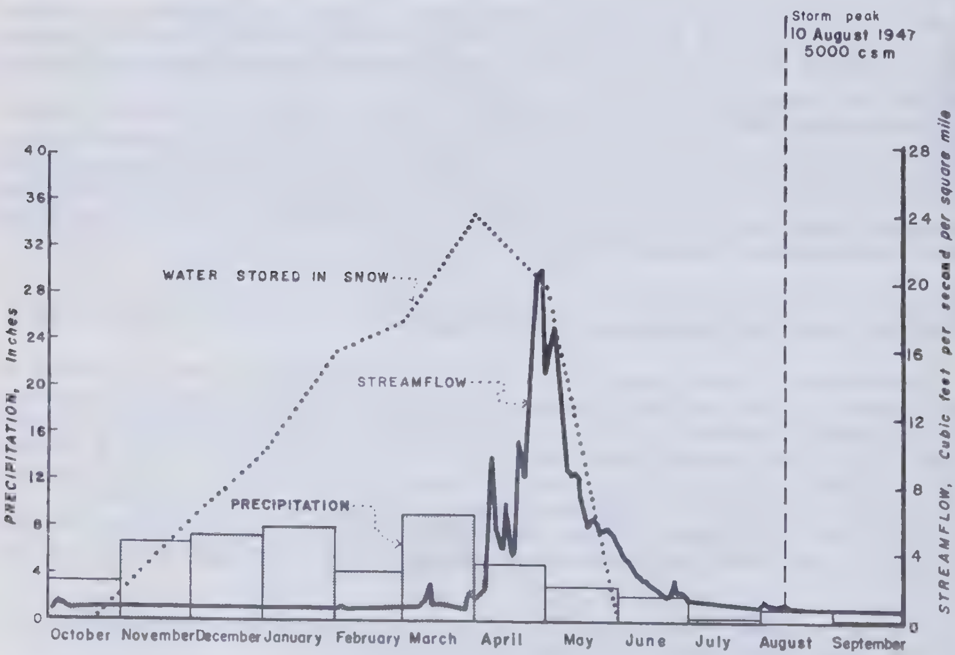

Fig. 2 — Streamflow, Halfway Creek, for the water-year 1951-1952 (with peak flow of mud-rock flood of 10 August 1947 superimposed) and water stored in snow and monthly precipitation at the nearby Rice climatic station.

ar), is more than enough to replace the water extracted from the soil by evaporation and piration during the preceding growing season. Thus, water available for seepage to springs hannels is in excess of the amount needed to recharge the soil to its water-holding capacity. surplus water causes the streams to rise in the spring and maintains their flow through the ummer, autumn, and winter months (fig. 2).

INTER STREAMFLOW

When snowpack formation commences in early winter, streamflow is low because seepage evapotranspiration losses have lowered the water table so that only lower aquifers still ain water. Their yield to streamflow is constant and depends mostly upon the permeability e soil mass. Little or no diurnal fluctuation is due to evapotranspiration, and only rarely ere any discharge to streams through upper aquifers from melting snow or unseasonal storms.

TABLE 1

Twelve-year average monthly and seasonal streamflow, Halfway Creek watershed

Season	Month	Streamflow (inches)	Percent of average annual
	December	0.811	3.8
	January	.942	4.4
	February	1.152	5.3
nter		2.905	13.5
	March	2.042	9.5
	April	4.546	21.1
	May	5.253	24.4
ing		(*) 11.840	55.0
	June	2.773	12.9
	July	1.038	4.8
	August	.850	4.0
mmer		4.661	21.7
	September	.710	3.3
	October	.694	3.2
	November	.705	3.3
itumn		(*) 2.110	9.8
otal annual		21.516	100.0

(*) Disagreement is due to rounding off numbers in components.

4. Spring streamflow

Slightly more than one-half of the average annual streamflow comes in the spring snow is melting (table 1). In contrast to that of winter, spring streamflow is extremely s tive to the prevailing weather conditions such as temperature and precipitation, and from Halfway Creek drainage may fluctuate from a daily average of 0.06 csm to more than

Snow melting causes a diurnal fluctuation in streamflow; it increases in the afternoon decreases during the night and early morning. Spring rainstorms may cause a sudden ri streamflow at any time of day or night.

Although most of the spring runoff is due to snowmelt, as much as 40 percent of the an total may, in some years, be due to spring rains ([1]). Precipitation during the spring snow period produces more runoff than equal amounts of rain or snow during autumn and wi Much of the autumn and winter precipitation is required to fill the capillary storage capa of the soil, but since this takes place during the spring snowmelt, little of the spring rain ca so retained. Hence, most of it moves through the soil and into the streams.

The instantaneous maximum snowmelt peak is a combination of a diurnal snow fluctuation superimposed upon a high base flow (fig. 3a). The diurnal increment is mo seepage flow, but part of it is channel interception of melting snow bridges that remain

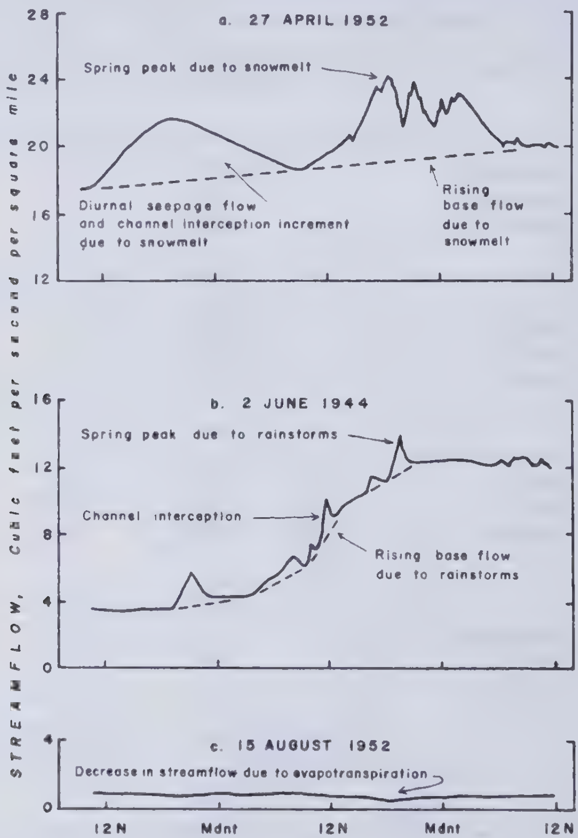

Fig. 3 — Examples of daily streamflow from Halfway Creek.

Fig. 4 — Snow remaining in Halfway Canyon near time of spring peak. (*Forest Service photo.*)

all channels in the headwaters (fig. 4). The base flow rises in the spring as the soil becomes with snowmelt water. When the entire soil profile is filled the deeper aquifers produce a atively large amount of water, and even the surface soil may yield water to small rills and nnels. Overland flow seldom occurs during the snowmelt period, although snowmelt water y sometimes be within the soil only momentarily before being returned to the surface as rill channel seepage flow (fig. 5).

Fig. 5 — Water being returned to surface after being in soil mantle only temporarily: (a) Water rodent burrow covers man's fingers;

(b) dark area below and to left of man's hand is soil moistened by water running from rodent burro
(*Forest Service photo.*)

An extended rainy period soon after the snowmelt peak has passed may cause a seconda seepage flow peak even higher than the one caused by melting snow (fig. 3b). This occurs wh a heavy rain falls on a wet soil, or when more than enough rain falls to refill a partially c soil. In this case, a high channel interception peak is superimposed on a high base flow.

To date, the highest instantaneous spring peak recorded at Halfway Creek on the Da County Experimental Watershed is 24 csm on 27 April 1952. The exact amount of season precipitation that contributed to this peak is not known, but a conservative estimate is abc 43 in—the total catch in a storage gage at an index station near the channel of Farmingt Creek at 6,850 ft elevation during the period 1 October 1951 to 1 May 1952.

5. Summer streamflow

Streamflow following the spring peak decreases throughout the summer. This recessi is rapid at first, but becomes slower as summer progresses. In late summer the flow curve wou appear as an almost flat line if it were not for the daily evapotranspiration fluctuation. T fluctuation is much less pronounced and the reverse of that during snow melting in the sprin the rise occurring in the morning and the decrease in the afternoon (fig. 3c).

The normal summer streamflow curve is interrupted temporarily by rises caused by oc sional rainstorms. Maximum heights of these rises vary considerably. Most of them are sm in keeping with the size of the summer storms, and their only contribution to streamflow the amount of water that falls directly into stream channels. But, if the watershed has been abused that the soil on a small but critical area (in some cases 10 per cent or less) is expo to the beating action of the rain, the surface soil becomes puddled; rain water fails to infiltr as fast as it falls, and some of it runs over the surface to the channels. This overland flow n produce a mud-rock flood with an instantaneous peak much higher than the highest spr peak (fig. 2).

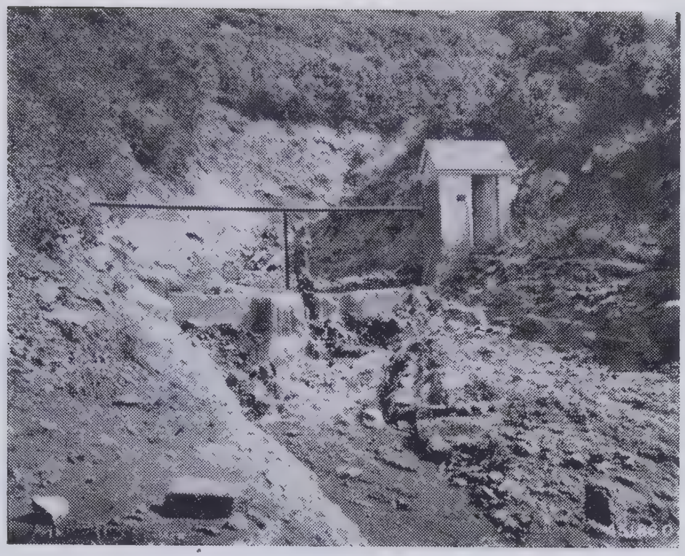

Fig. 6 — Halfway stream gaging station after mud-rock flood of 10 August 1947. Tapes show width and depth of peak flow. (*Forest Service photo* ≠ 451860.)

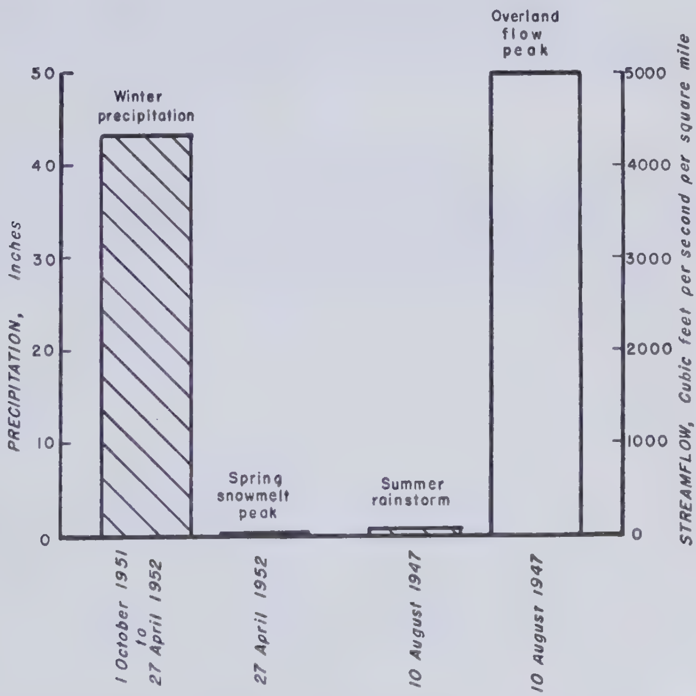

Fig. 7 — Contrast between a spring and summer streamflow peak and the precipitation that caused them.

In past years, soil on parts of Halfway Creek watershed, as on many other Intermounta watersheds, was so exposed by overgrazing. On 10 August 1947, a rainstorm of 0.79 in f in 115 min with 0.42 in falling during the most intense 5-min period. This storm caused a sur of water, mud, rocks, and other debris that had a channel width of 28 ft and a depth of 8 (fig. 6). A discharge rate for this peak was estimated by means of the minimum energy relatio ship to be about 5,000 csm ([3]).

The height of this summer flood peak contrasts sharply with the height of the maximu spring peak of 1952 (fig. 7). In the latter, the 43 in of precipitation accumulated at the index stati at 6,850 ft elevation during the 7 mo, 1 October 1951 to 1 May 1952, resulted in a peak of 24 cs In the former, 1/55 as much precipitation from an intense summer rainstorm produced a pe more than 200 times as high—5,000 csm (fig. 7).

Except for occasional interruptions by summer storms, flow of these streams continues diminish throughout the summer and reaches a low point in late summer or early autum Minimum flow depends upon the date of the spring peak, height of spring peak, amount precipitation during the summer, and the length of the growing season.

6. Autumn streamflow

The summer recession of streamflow ends in the autumn when killing frosts cause deciduo plants to shed their leaves. Evapotranspiration losses decrease and since streamflow is relative low, a decrease in the high evapotranspiration losses of the riparian vegetation often resu in a discernible increase in streamflow ([2]).

Autumn rainstorms may sometimes begin wetting the dry soil but usually the buildu of the winter snowpack begins before the soil's capillary capacity is filled. Therefore, no surpl water is released to the streams until the snow melts in the spring and the flow of those strear that head in the high mountains remains almost constant throughout the winter. Ordinaril autumn has the smallest proportion of the average annual streamflow (table 1).

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DISCONTINUITY OF DISCHARGE OF UKRAINIAN RIVERS

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Discontinuity of discharge is a typical feature of the hydrological regime of small rivers the Ukraine and should be taken into consideration when carrying out measures for their lization. Under the conditions of the Ukraine, cessation of discharge may set in as a result exhaustion (cessation) of feeding, as well as the passing of rivers into alluvial deposits, ing the bed; in areas of the occurrence of karst the stream may be absorbed by the karts sys-n.

Cessation of discharge under natural conditions may set in during the warm season, ien losses due to evaporation are not covered by the afflux, and in this case it is called drying; ring the cold season, it may set in as a result of freezing of water on the surface and of the ths of underground feeding; finally, cessation of discharge may set in at any season as a sult of the stream passing (submerging) into a stratum of alluvial deposits or into a karst stem. The conjunction of various natural factors affecting the discontinuity of the discharge rivers makes it impossible, in many cases, to fix the exact dates of the beginning and end of s phenomenon and to determine its genesis. Thus, in the southern areas of the Ukraine, iere the effective precipitations (forming the discharge) occur at lengthy intervals, and where ssation of discharge beginning in summer may last through the winter and vice versa, the nesis of the phenomenon may be only roughly established.

It should be noted that this phenomenon has been inadequately studied—not all small vers are under systematic observation, and data covering long periods are lacking. In addition, servations are made difficult because of economic activity (water gates for various purposes, illways in rivers of different discharges, regulation of discharge, etc.). It is practically impos-ble to take into account all the diversified influences of human activity, and to estimate them antitatively and differentiate them in time. Great difficulties arise on studying cessation of scharge in areas of karst occurrence (the Crimea, Donets Basin, Carpathians, Dyesna area), iere absorption of surface streams and interbasin migration of waters are possible.

The formation of the discharge of Ukrainian waters is due to surface (atmospheric) and nderground feeding. The magnitude of the surface feeding depends on the regime of atmos-heric precipitations (magnitude, intensity, distribution in time and area) and the degree of sses due to evaporation and infiltration. It is known that the sum of precipitations over long eriods (a year, a season) varies uniformly in the plain area of the Ukraine. However the losses precipitations by evaporation and infiltration depend on local conditions (inclination and smemberment of the basin, absorptive capacity of the soil) which ordinarily vary greatly ver the area. Hence, equal sums of atmospheric precipitations may have diverse effects on e formation of the discharge in contiguous basins. Atmospheric precipitations cannot there-re be taken as indications for the characteristics of the discontinuity of river discharge.

The magnitude of the underground feeding depends on the thickness and productivity the water-bearing horizons bared by the rivers and is therefore of a distinctly local character, ianging sharply as one moves through the area. On the territory of the Ukraine, underground eding does not in many cases secure constancy of discharge in small rivers.

These considerations lead to the conclusion that generalizations as to the discontinuity f the discharge of rivers can be drawn only in regards to certain districts, where the conditions f the underground and surface feeding change uniformly over the area. These same conditions idicate the inexpediency of drawing general conclusions about the discontinuity of discharge or large territories in the form of isolines, and the extremely limited opportunities for applying nalogies. The characteristics of discontinuity of discharge of the small rivers of the Ukraine re, therefore, considered in respect to separate geomorphological districts of the territory, which no sharp variations have been noted in the conditions of underground feeding of the ri-ers. Five such districts have been distinguished on the territory of the Ukraine : Seaboard,

Steppe, Central, Northern, Carpathian. When marking out the districts, consideration w given to the data on the discontinuity of discharge, and to the geomorphological, hydrogeologi and climatic conditions.

1. *The Seaboard district* occupies the southern, most arid part of the territory of t Ukraine, adjoining in a narrow strip the shores of the Black and Azov Seas and including t Crimean peninsula. The northern boundary of the district passes approximately through t line : mouth of the Prut-Krivoy Rog, upper reaches of the Molochnaya River. The territory level (except for the highlands of the Crimea), mostly covered by a thick loess layer, insu ciently moistened by atmospheric precipitations. The water-bearing horizons are in sands w interlayers of sandstones and limestones, as well as in Pontian limestones. The water-beari horizons are covered by thick strata of loess (up to 20 m, and over), rarely opened up by valle of small rivers and insignificant in the feeding of the latter. There are very favourable con tions in the district for considerable losses of precipitations due to evaporation and infiltratio

The discharge of rivers fed in this district is usually observed in spring and after rai All the rivers of this district cease to discharge for a long time every year, and lack of is mo usual than presence of discharge. There have been cases when the absence of discharge last over a year (the rivers Tiligul, Sarata, Maly Kuyalnik) and even two years running (the Cl chikleia, Bolshoi Kuyalnik). Absence of discharge is most often noted from May to Februa inclusive. No distinct dependence is noted for the rivers of this district, even qualitative between the duration of absence of discharge and the water collection areas; in most cas the duration of absence of discharge increases with an increase in water collection area. Wi an insignificant amount of underground feeding, this circumstance is natural, since a consid rable part of the discharge is expended along the river on evaporation and infiltration and cann be compensated by the run-off formed in the upper part of the basin.

The subdistrict of the Crimean mountains is distinguished in this area. Here the pre pitations are 2-2.5 times as great as on the surrounding plains and the evaporation losses a considerably less. Cessation of discharge of the Crimean rivers occurs in many cases as a con quence of their passing into a stratum of alluvial deposits, filling the channel, or into ka systems, where they usually continue to function. This latter circumstance has long been know to the local population, who have great experience in the utilization of such streams for econ mic purposes by accumulating their waters in river beds by means of various barriers.

The very intensive utilization of the waters of Crimean rivers for irrigation and wa supply makes it difficult to determine exactly the length and the recurrence of periods of abse of discharge. In average figures, the duration of absence of discharge (to the surface) ordinary years may be estimated as 2-3 months, in low-water years as 4-6 and in particula dry years as 9-12 months.

A drainless-bottom subdistrict is also distinguished in the Seaboard district area. It located between the Dnieper and Molochnaya rivers. The dry valleys of this area are fill with water, and streams may arise in them, only rarely, in spring after showers. Howev these streams are temporary, rarely lasting more than 2-3 months. Even while the stream is fu tioning it does not reach the sea or a river with a constant flow, but is lost in the steppe, filli depressions in the relief.

2. *The Steppe district*, adjoining the Seaboard district, occupies a large part of the sou of the Ukraine, its northern boundary passing near the arbitrary line of demarcation betwe the steppe and forest-steppe zones. The territory of the district is level, dismembered by a de network of rivers and ravines, which sets up favourable conditions for the feeding of atmosphe waters into the river systems. This area is frequently affected by droughts, the recurrence which is estimated as once in five years. The conditions of underground feeding of rivers a better here than in the adjoining Seaboard district, the river valleys baring water-bearing ho zons in many cases; the underground feeding does not. however, ensure a constant flow the rivers everywhere. Besides, there is in this district a great diversity in the conditions

underground feeding, both in adjoining rivers and along individual rivers (the Kodyma, Kuchurgan, Kogilnik, Tiligul, Konskaya, Samara, Mokrie Yaly and others).

Discharge frequently ceases for a long time in the rivers of this district too. There is also no definite dependence for the rivers of this district between the duration of absence of discharge and the water collection areas; many rivers of the district begin to dry up not in the upper reaches, but in the lower-lying sections (the Bereka, Konskaya, Kodyma, Orgol, Mertvovod, Chichikleia, Yalpukh, Kogilnik, Byk, Kuchurgan and others).

In respect of discharge cessation conditions in the territory of the district, the subdistrict of the Donets Ridge (Donets Basin) is distinguished; here the geomorphological and climatic conditions are such that the duration of absence of discharge is shorter than in the contiguous areas of the district. The economic utilization of the Donets Basin rivers for water supply, as well as for run-off of mine and industrial waters, greatly complicates the study of the natural regime of the rivers. It may be noted that the regulation of the discharge of some Donets Basin rivers is as high as 100 per cent, while the run-off discharges constitute 13-18 per cent of the natural discharge (Krivoy Torets, Bolshaya Kamenka, Lugan).

Most of the rivers of the district have a discontinuous discharge; the greatest water collection area of the rivers with a discontinuous discharge is 9500 sq. km (the Oryol). The duration of absence of discharge varies within a considerable range; in very dry years it may last 6-7 months and in some rivers (Sarata, Aliyaga) up to 10-12 months. In the Donets Basin subdistrict the absence of discharge is in ordinary years 1-4 months, and in dry years up to 7 months.

A certain difference in the conditions of drying is noted in the right-bank and left-bank (in respect to the Dnieper) parts of the district.

3. *The Central district* adjoins the Steppe district and occupies a considerable part of the territory of the Ukraine, its northern boundary passing approximately through the line : Bar - Kiev - Vorozhba. The surface is level, cut up by river valleys and ravines, which often open up water-bearing horizons. The district lies in a zone of normal moistening by atmospheric precipitations.

The conditions of the atmospheric and underground feeding of rivers may be considered satisfactory here; they cannot, however, ensure the constant flow of all rivers, especially in dry years. A feature of the district is the considerable diversity in the incidence and duration of absence of discharge and, especially, in the crystalline massif zone (basins of the Southern Bug, Rosi). It frequently happens here that of two adjacent rivers, one has a discontinuous discharge and the other a continuous one. Such cases are due to a sharp change in the underground feeding conditions.

The Dnieper valley divides the territory of the district into two parts, in which the conditions for discontinuity of discharge of the rivers differ to some extent.

In average figures, absence of discharge of small rivers in the district lasts 3-4 months in dry years, and 8-10 and even 12 months in very dry years.

4. *The Northern district* occupies the northern part of the territory of the Ukraine from the administrative borders to the Central district. On the west, it adjoins the Carpathian district, the line of demarcation between these districts passing approximately through the line : Sambor - Stry - Kolomiya. The district is distinguished by normal, and in the western part by heavy moistening by atmospheric precipitations, dry periods occurring rarely. The district has extensive swampy areas, particularly in the basins of the right-bank tributaries of the Pripyat. The underground waters of the district occur near the surface, and are opened up in many places by river valleys; in such cases, good underground feeding is assured.

The conditions of atmospheric and underground feeding of the rivers thus ensure a continuous stream, and cessation of discharge is here regarded as an unusual event. Cessation of discharge may set in for short periods—in ordinary years up to 1 month, and in dry years up to 3-4 and even 6 months.

A subdistrict is distinguished here, having a considerable bogginess of area (10-20 per cent) and thick peat beds. Cessation of discharge in this subdistrict being so unusual and involving only small streams, it has to be taken into account only in very careful calculations.

5. *The Carpathian district* occupies the territory lying to the west of the line Sambor - Stry - Kolomiya. In this district there exist rivers belonging to the basins of the Tissy, Dniester Prut. The presence of the Carpathian Mountains causes a considerable dismemberment of the area, great inclines, and sharp changes in the humidity conditions. The district lies in the zone of sufficient and heavy (at altitudes of over 500 m above sea level) moistening by atmospheric precipitations. Abundant and frequent rains, as well as relatively small losses due to evaporation and infiltration set up favourable conditions for the formation of continuous river discharges. Cessation of discharge in this district is observed only in small streams with basin areas up to 200 sq. km. and does not exceed four months. It may be noted that on the northeastern slopes of the Carpathians cessation of discharge is more probable in the winter months.

A narrow strip adjoining the Tissy River is distinguished by ist geomorphological and climatic features. The discharge-forming conditions differ sharply here from mountain conditions - precipitations are less, inclines of the terrain are slight, and cessation of discharge is more probable than in the mountainous part. However, there is almost no necessity for taking into account these facts, since the area is covered by a network of drainage canals carrying the waters that enter into them when the Tissy overflows.

On the basis of an analysis of the data on the discontinuity of discharge of small rivers of the Ukraine, generalizations have been drawn for each district, and the most typical features of this phenomenon are given (see table 1).

Characteristics of Discontinuity of Discharge of Small rivers of the Ukraine

District	Greatest water-collecting areas of rivers with discontinuous discharge	Duration of periods of absence of discharge (in months)			Maximum probable periods of absence of discharge
		Ordinary years	Dry, low-water years	High during observation period	
1. Seaboard	No limitation of area	2-6	9-12	26	V-IX
2. Steppe	9 500	2-3	6-7	12	VI-VIII
3. Central	3 900	up to 1	3-4	12	VI-VIII
4. Northern	800	up to 1	2-4	6	VII-IX
5. Carpathian	200	—	up to 2	4	I-II

When determining the characteristics presented in table 1, it was, of course, impossible take completely into consideration the local hydrogeological features having a substantial ct on the discontinuity of discharge of small rivers. With careful hydrological calculations, real durations and recurrences of discontinuity of discharge must therefore be determined the basis of investigations of streams in their localities.

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III. PARTIE ADMINISTRATIVE
III. ADMINISTRATIVE PART

A) A. I. H. S.

CALENDRIER AIDE MÉMOIRE.

1. Colloque d'Athènes du 11 (et non du 12) au 20 octobre 1961

a) Présentation des résumés avec nom d'auteur et titre — avant le 1er février 1961.
b) Présentation des rapports complets — avant le 1er juin 1961.

2. Colloque sur l'Erosion Continentale 1962
Bari (Italie)

Les premiers détails sont donnés dans ce bulletin.

3. Colloque sur les fluctuations des glaciers actuels à Obergurgl (Tyrol) Autriche en septembre 1962. (du 10 au 18).

Annoncer sa participation ou l'énvoi d'une communication avant le 30 juin 1961. (à l'aide d'un formulaire à envoyer au Secrétaire de la Commission).

A) I. A. S. H.

DIARY OF EVENTS REMINDER

1. Symposium at Athens 11-20 Octob (en not 12-20) 1961

a) Delevery to Secretariat of summ ries, each including author's name a title of paper, before 1st Febr. 1961.
b) Delivery to Secretariat of comple papers — before 1st June 1961.

2. Symposium on Continental Erosic 1962
Bari (Italy).

The first details in this Bulletin.

3. Symposium on the variations existing glaciers at Obergurgl (T rol) Austria 10-18 September 196

Any one who is likely to attend t Meeting, or to submit a paper should co plete a form and send it to the Secreta of the Commission before 30th June 196

. COMPTES - RENDUS DES SÉANCES DU CONSEIL ET DES ASSEMBLÉES GÉNÉRALES A HELSINKI EN JUILLET-AOUT 1960

a) Réunion du conseil du 25-7-60

ORDRE DU JOUR

1. Rapport du Secrétaire. Discussion
2. Association de Glaciologie?
3. Comité des Nominations.
4. Relations avec l'UNESCO
5. Relations avec W.M.O.
6. Relations avec d'autres Organisations.
7. Bibliographie
8. Marées terrestres
9. Divers.

1. *Discussion du rapport du Secrétaire et particulièrement de la situation financière actuelle.*

L'exposé du Secrétaire (voir le rapport du secrétaire, bulletin 18) et la discussion qui suivit furent très longs. La plupart des orateurs insistèrent sur la nécessité de limiter les dépenses pour publications tout en remarquant que ces publications ont pris une telle place dans le monde hydrologique qu'il ne peut être question de les réduire à des formes squelettiques, loin de là. D'autre part la possibilité d'obtenir des ressources plus élevées de l'U.G.G.I. est très problématique. Un comité de trois membres M. LANGBEIN, VOLKER et SCHUMSKY fera rapport sur cette question des publications.

2. *Association de Glaciologie?*

Le secrétaire fait part de la lettre de M. AVSIUK proposant la création d'une telle Association indépendante. Le Président propose la constitution d'un comité pour étudier cette question et faire rapport avant la fin de l'Assemblée. En feront partie : MM. WILM, TISON, AVSIUK, SCHUMSKY, FINSTERWALDER et WALD.

3. *Comité des Nominations*

MM. SCHOELLER et DE QUERVAIN, membres de l'ancien Comité voudront bien prendre part aux travaux du nouveau comité dont fera également partie Monsieur AVSIUK.

4. *Relations avec l'UNESCO*

Le Secrétaire, dans son rapport, a exposé l'état de ces rapports dont l'Association a lieu de se féliciter. Le Conseil lui demande de continuer dans la même voie.

Les autres points seront discutés au cours d'une séance ultérieure.

b) Réunion du conseil du 28-7-60

ORDRE DU JOUR

Identique à celui de la séance du 25/7/60.

1. La discussion est reprise sur la question des publications. Après divers exposés, o décide d'attendre les propositions du comité désigné au cours de la première séance.

2. La question de la création d'une Association de Glaciologie est remise à la séanc suivante.

3. Il en est de même pour les propositions du Comité des Nominations.

4. Au sujet du Colloque sur les Ressources en Eaux Souterraines à organiser en colla boration avec l'Unesco, le Secrétaire précise qu'il aura lieu en Grèce au cours du dernier tr mestre de 1961. Il signale également que plusieurs pays comme les Etats-Unis, l'U.R.S.S ont déjà fait connaître leur intention de participer très sérieusement à ce colloque.

5. Le Secrétaire signale la création de la Commission hydrologique de l'O.M.M. El sera présidée par notre ami M. Kohler. Cette désignation est un gage pour l'avenir des relation entre les deux Associations.

La prochaine séance du Conseil aura lieu le 4 août à 14 h 30.

Présents :

RAY K. LINSLEY	U.S.A.	R.N. WILSON	U.S.A.
MAX A. KOHLER	U.S.A.	WILLIAM C. ACKERMAN	U.S.A.
A. BOGOMOLOV	U.S.S.R.	LOPEZ DE AZCONA	ESPANA
L. SERRA	FRANCE	TONINI	ITALIE
K. UBELL	HUNGARY	GAZZOLO	ITALIE
K. SZESZTAY	HUNGARY	JAKHELLN	NORWAY
W. FRIEDRICH	GERMANY	W.F.J.M. KRUL	NETHERLAND
P. KASSER	SPISSE	TIXERONT	TUNISIE
R.H. CLARK	CANADA	WILM, Président.	
W.B. LANGBEIN	U.S.A.	TISON L.J., Sécrétaire.	

c) Réunion du CONSEIL, du 4 août 1960

ORDRE DU JOUR

1. Propositions du Comité de Nomination
2. Relations avec O.M.M.
3. Relations avec autres organisations
4. Neiges et Glaces
5. Publications de l'Assemblée d'Helsinki et Symposia

c) COUNCIL Meeting of 4th Aug. 196

AGENDA

1. Proposals of the Nomination Committe
2. Relations with W.M.O.
3. Relations with other organizations
4. Snow and Ice
5. Publications

6. Publications futures	6. Publications in the future
7. Bulletin	7. Bulletin
8. Bibliographie	8. Bibliography
9. Colloque sur Intertropical Geophysics	9. Symposium on Intertropical Geophysics
10. Conférence Internationale sur les nuages	10. International Clouds Conference
11. Comité pour l'étude de la dynamique et de la morphologie des littoraux marins	11. Committee for the study of the Dynamics and Morphology of the Marine Littorals
12. Centenaire A.I.G.	12. 100 years I.A.G.
13. Comité sur les isotopes en Géologie, la chimie du Globe, etc.	13. Committee on Isotop Geology, Geochemistry, etc.
14. Service permanent des substances solides transportées	14. Permanent Service of Sediments.
15. Marées terrestres	15. Tides of the Earth's Crusts
16. Hydrométrie	16. Hydrometry
17. Faut-il deux Assemblées Générales partielles?	17. One or two General Assemblies?
18. Comité International de Géophysique	18. Internation Committee of Geophysics
19. Comité des Instruments	19. Committee of Instruments
20. Colloque sur les changements climatiques	20. Symposium on climatic changes
21. Cartes des Eaux souterraines	21. Maps of Ground Waters
22. Questions pour 1963	22. Questions for 1963
23. Comité de Standardisation	23. Committee on Standardization
24. CCTA — Commission de Coopération Technique en Afrique	24. C.G.T.A. Meeting of Naïrobi
25. Programmes.	25. Programs

Présents :

V. ALLARD	BRITAIN	G. BOGOMOLOV	U.S.S.R.
. SCHUBERT	GERMANY D.R.	K. SZESZTAY	HUNGARY
W. FRIEDRICH	GERMANY	ANTON JAKHELLN	NORWAY
LOPEZ DE AZCONA	ESPANA	A. VOLKER	HOLLAND
WILLIAM C. ACKERMANN	U.S.A.	H. SIMOJOKI	FINLAND
EDWARD A. JOHNSON	U.S.A.	S. MANDEL	ISRAEL
W.B. LANGBEIN	U.S.A.	L. SERRA	FRANCE
. KASSER	SCHWEIZ	S. BUCHAN	G.B.
J.H. CLARK	CANADA	H. KURON	GERMANY
MORANDINI	ITALY	H. WILM, President	
OLIVERTI	ITALY	L.J., TISON, Secretary	

Le Conseil discute les propositions du Comité des nominations et établit la liste suivante.

Président : Dr. W. FRIEDRICH (Allemagne) Kaiserin Augusta Anlagen, 15 Koblenz.

Vice-présidents : Prof. D. TONINI (Italie) S. Marco 4423/A, Venezia
Prof. V. BOGOMOLOV (U.R.S.S.) Staromonetny per. 35 Moscou V—17
Dr. C. WALLEN (Suède) Sveriges Meteorologiska och Hydrologiska Institut, Stockholm 12

Secretary: Prof. L.J. TISON, (Belgique) rue des Ronces, 61 Gentbrugge.

Commission neiges et glaces

Président : P.A. SHUMSKY (U.R.S.S.) Institut du Sol glacé, Cherkassky Per 2/10, Moscou B

Vice-présidents : Mr. A. BAUER (France) rue Geiler, 46, Strasbourg
Prof. MORANDINI (Italie)
Mr. W. FIELD (U.S.A.) Osgood Head American Geographical Society Broadway 156th Str. New-York 32—U.S.A.
Secretary : Mr. W. WARD (Grande Bretagne) 147, Rickmansworth Rd, Watford, Hert England.

Commission des eaux souterraines

Président : Prof. G.B. MAXEY (U.S.A.) State Geological Survey, Urbana Ill.
Vice-présidents : Dr. S. BUCHAN (Grande Bretagne) Exhibition Road, South Kensington London S.W. 7
Mr. HAZAN (Maroc) Ministère de la Production industrielle et des Mines Rabat.
Mr. MANDEL (Israël) 54, Ibn Gevirol Street, Tel Aviv.
Secretary : Mr. SANTING (Hollande) 13, Parkweg, 's-Gravenhage.

Commission des eaux de surface

Président: Mr. L. SERRA (France) 6, quai Watier, Chatou (S. et O.).
Vice-présidents : Mr. A. VOLKER (Hollande) 25, Koningskade, 's-Gravenhage
Mr. SIMOJOKI (Finlande) Hydrografinen toimisto Fabianinkatu 25, Helsinki
Mr. T. GAZZOLO (Italie) Via Nomentana, 2, Roma
Secretary : Mr. P. KASSER (Suisse) Gloriastrasse, 39, Zurich.

Commission érosion continentale

Président Prof. H. KURON (Allemagne) Ludwigstrasse, 23, Giessen
Vice-présidents: Dr. F. FOURNIER (France) B.I.S., rue Cuvier, 57, Paris 5e
S. EL ZEIN (Soudan)
Secretary: Mr. MADDOCK (U.S.A.) Geological Survey, Washington 25, D.C.

Le Président H. WILM déclare que les présidents des Comités seront désignés par le nouveau Président de l'A.I.H.S.

2. Relations avec O.M.M. — Relations with W.M.O.

Le Secrétaire présente un historique de ces relations et termine en faisant part de la création de la Commission hydrologique de l'O.M.M. Le Secrétaire pense que l'A.I.H.S. n'a plus à discuter cette création et souhaite que les deux organisations fassent de leur mieux pour avoir de bonnes relations et pour s'aider entre elles. Il signale enfin que l'O.M.M. a décidé de donner à l'A.I.H.S., pour chacune des trois prochaines années, une subvention de 500 $ pour la bibliographie hydrologique.

3. Relations avec les autres organisations.
Le Secrétaire rappelle ce qu'il a dit dans son rapport financier et moral. Aucun commentaire.

4. Le Président et le Secrétaire présentent les conclusions de la Commission chargée par l'Assemblée Générale de discuter la proposition de Monsieur AVSIUK tendant à la création d'une Association des Glaciers.

Résolution de la réunion tenue à Helsinki

1) Il ne sera pas créé d'Association de Glaciologie au cours des trois prochaines années.
2) Le Président de la Commission des Neiges et des Glaces sera, ex officio, un membre avec droit de vote, du Conseil de l'A.I.H.S.

3) La Commission des Neiges et des Glaces tiendra une Colloque sur les variations des aciers actuels, en 1962.

4) Les Comités nationaux d'Hydrologie Scientifique établiront des sous-comités pour la ige et les Glaces et désigneront des correspondants nationaux pour cette commission.

Le rapport est adopte.

Resolutions of meeting held in Helsinki

1) No Association for Glaciology should be formed in the next 3 years.

2) The President of the Commission of Snow and Ice should be a voting member, ex-icio, of the Council of the Association of Scientific Hydrology.

3) The Commission of Snow and Ice will hold a Symposium on the variations in existing ciers in 1962.

4) The National Committee for Scientific Hydrology should establish subcommittees for ow and Ice and National Correspondents for the Commission of Snow and Ice.

Pour l'Assemblée d'Helsinki, dont on a commencé la publication des rapports, on continuera à publier toutes les publications présentées en temps utile.

Pour l'avenir, le Comité constitué lors de la réunion précédente du Conseil présente son rapport :

Limitation du nombre de rapports sur l'hydrologie

Le nombre toujours croissant de rapports présentés aux séances de l'A.I.H.S. et dont frais de publication constituent une lourde charge pour le budget de l'Association, nous a nduit à examiner les mesures à prendre pour arriver à une limitation effective du nombre de s rapports.

Afin d'élaborer à ce sujet des recommandations, un petit groupe de travail a été constitué ns lequel figurent :

A. Volker (Hollande) président
W.B. Langbein (Etats-Unis)
P.A. Shoumsky (U.R.S.S.).

Ce groupe a rejeté la formule qui consisterait à limiter le nombre de publications à im-imer aux frais de l'Association pour les pays-membres d'après les quota payés par eux.

A l'unanimité le groupe s'est mis d'accord sur les recommandations suivantes :

1) Il y aura une sélection de rapports basée sur l'intérêt général et la qualité scientifique s rapports.

2) Les Comités Nationaux refuseront des rapports publiés antérieurement et indiqueront uels rapports seront destinés à être publiés ailleurs.

3) La sélection des rapports aura lieu séparément pour chacune des commissions de A.I.H.S.

4) Il sera formé au sein de chaque Commission un comité de sélection de trois personnes désigner par le Président de la Commission; le Président pourra être membre de ce comité.

5) Les comités de sélection se réuniront pendant les manifestations de l'Association pour oisir les rapports qui seront publiés en priorité aux frais de l'Association.

6) A titre informatif, l'administration de l'Association indiquera en temps opportun aux omités Nationaux le maximum désirable de rapports à présenter par chaque pays; de cette çon il sera possible de procéder à une sélection préliminaire de papiers.

7) Les rapports des comités ne seront pas à la charge des quota nationaux des auteurs.

8) Les délais pour l'envoi des rapports à l'administration de l'Association devront être rupuleusement observés.

9) Les mesures envisagées ne seront pas applicables au Congrès 1960 de Helsinki.

Limitation of the number of papers on hydrology

In view of the ever increasing number of papers presented at the meetings of the I.A.S.H it was felt desirable to arrive at an effective limitation of the number of papers to be printe at the expense of the Association.

In order to make the necessary recommendations, a small study group was set up, con sisting of the following members :

A. Volker (Holland), Chairman
W.B. Langbein (U.S.A.)
P.A. Shoumsky (U.S.S.R.).

In lieu of the idea of adopting a certain maximum for the number of papers with allo cations for the member countries in accordance with the quota paid by them, unanimousl the group accepted the following recommendations :

1) There will be a screening of papers on the basis of general significance and scientifi quality.

2) The National Committees will report that manuscripts submitted have not been publis hed previously and will state which manuscripts are intended for publication elsewhere.

3) Screening will be carried out separately by each Commission of the I.A.S.H.

4) The President of each Commission will nominate a screening committee consisting o three members; he is free to consider himself as one of the members.

5) The screening committees will held their sessions during the meetings of the Associatio to decide which of the papers presented at those meetings should have priority in printing

6) By way of a first guide the officers of the Association will inform well ahead of the meet ings the National Committees on the desirable maximum number of papers to be submitte by each country; in this way a preliminary screening of papers by the National Committee may be obtained.

7) Committee Reports will not be charged against the national quotas of the author

8) Deadlines for receipt of manuscripts should be rigorously observed.

9) The regulations mentioned above are not applicable to the Helsinki Congress 196

7. Bulletin

Sur proposition du Bureau, la résolution suivante est adoptée :

Chaque pays aura un représentant chargé :

1) de récolter des abonnements du Bulletin
2) de récolter de la publicité
3) de rassembler des communications pour le bulletin et de soumettre ces communication à un Comité national chargé d'émettre un avis sur leur valeur.

8. Bibliographie

La continuation de la publication de cette bibliographie, dans les mêmes conditions qu précédemment, est décidée.

9. Colloque sur la Géophysique Intertropicale.

Le Conseil décide que l'Association doit s'intéresser à ce colloque (voir la résolution n° 3

10. Le Conseil estime devoir intervenir à la Conférence des Nuages (voir résolution n° 6

11. Le Conseil adopte une recommandation par laquelle l'Association marque son intér pour le Comité pour l'étude de la Dynamique et de la Morphologie des littoraux marin C'est la résolution n° 5.

12. L'A.I.H.S. n'estime pas devoir s'occuper du centenaire de l'A.I.G.

Au sujet du Comité des Isotopes en Géologie et de la chimie du Globe, le Conseil décide d'associer l'A.I.H.S. à ces travaux. C'est la résolution 4.

A Toronto, Monsieur TIXERONT avait déjà marqué la nécessité d'avoir un organisme s'occupant de recueillir les données sur les transports solides en rivière. Plusieurs membres se sont demandé si la mission de la Commission actuelle des substances dissoutes ne pourrait pas être élargie pour s'occuper de sédimennts.
Le Conseil n'est pas de cet avis car la Commission des substances dissoutes a quasi terminé sa tâche. La Commission de l'érosion continentale semble la mieux à même de s'occuper de ces problèmes.

Le Secrétaire rappelle que les fluctuations de certains puits ne peuvent s'expliquer qu'en faisant intervenir l'action des marées terrestres. Un comité de l'A.I.G. s'occupe de cette question et a offert sa collaboration. Le Conseil marque son accord pour une semblable collaboration (résolution 7).

Le Conseil accepte la proposition introduite à la demande de Monsieur LASZLOFFY par le Secrétaire d'établir un Comité sur l'Hydrométrie (recommandation 8).

Le Conseil n'estime pas intéressant de scinder les Assemblées Générales.

Le Conseil marque l'intérêt de l'Association et surtout de sa Commission des Neiges et des Glaces pour le Comité International de Géophysique.

La création d'un comité d'Hydrométrie dont l'activité s'étendra aux instruments rend inutile le Comité des Instruments qui, fondé depuis 1951 n'a encore donné aucun résultat positif réel.

Le Conseil marque l'Intérêt de l'Association pour le Colloque sur les changements Climatiques (résolution n° 1).

Cartes des Eaux Souterraines.
Le Secrétaire rappelle que la Commission des Eaux Souterraines a constitué un Comité chargé d'examiner la question de la standardisation de ces cartes. Le comité a tenu plusieurs réunions et est arrivé à des conclusions qui ont été exposées dans les Comptes-rendus et Rapports; publication n° 52 de l'A.I.H.S.
Le Conseil fait siennes ces conclusions. Il est à remarquer que le Comité en question tout en ayant pu donner satisfaction au Comité des Zones Arides de l'UNESCO pour les cartes à petite échelle, doit continuer ses travaux pour les cartes à grande échelle. Le Comité devra se réunir avant la prochaine Assemblée Générale.

2. Questions à mettre à l'étude pour l'Assemblée Générale. Elles sont ou seront établies par chaque commission et chaque comité. L'ensemble de ces questions est donné dans ce bulletin.

3. La question du Comité de Standardisation est discutée. Le Secrétaire estime qu'il doit subsister et coordonner son travail avec celui de la Commission hydrologique de l'O.M.M. Adopté.

4. Commission de Coopération technique en Afrique. Cette commission organise un colloque sur l'hydrologie à Naïrobi en janvier 1961. Elle nous a aimablement invité à nous faire représenter. Monsieur Rodier est désigné à cet effet.

25. Monsieur LACLAVÈRE, secrétaire général de l'U.G.G.I. a demandé que les Association lui fassent parvenir leurs programmes à longue échéance. Ce programme pourrait serv à établir le rôle que joue l'U.G.G.I. dans le développement de la science et les profi que peuvent en retirer les nations qui s'intéressent à cette Union.
Ce programme, par commission, constitue l'Annexe III.

26. Le Secrétaire porte le télégramme suivant à la connaissance du Conseil.
Warszawa 64 28 1346.
Association internationale d'hydrologie scientifique bulevardi 40 helsinki.

Attention professeur TISON inondation désastreuse en Carpathes occidentaux m'empêch de quitter Pologne stop suis navré ne pouvoir pas prendre part session aihs stop souhai fructueux résultats pour le bien commun de tous pays stop envoie meilleurs voeux au burea de l'Association et a tous participants a la session. Prof. Dr. JULIAN LAMBOR POLOGNE.

ANNEXE I

TEXTE FRANÇAIS DES RECOMMANDATIONS ADOPTÉES À HELSINKI

Association Internationale d'Hydrologie Scientifique

Résolution n° 1

Considérant que l'UNESCO envisage d'organiser en étroite collaboration avec l'Organisation Météorologique Mondiale, en 1961 à Rome un Colloque sur les changements climatiques avec les sujets suivants :

1) Critères pour la détermination des tendances des fluctuations climatiques.
2) Données necessaires pour déterminer les changements climatiques.
3) Techniques, par exemple utilisation de radio-carbone dendrochronologie, paléorotanique, mesures de températures paléologiques, fluctuation des glaciers, etc.
4) Théories des changements climatiques.
5) Faits saillants des fluctuations climatiques.
6) Conséquences des changements climatiques sur la geomorphologie, les sols et l'ecologie des plantes et des animaux.
7) Recherches futures.

L'Association Internationale d'Hydrologie Scientifique exprime par la présente Résolution, le désir de participer à ce très important Colloque.

Résolution n° 2

Considérant la nécessité d'une étude de la variation des glaciers existants.

L'Association Internationale d'Hydro-

ANNEX I

ENGLISH TEXT OF THE RECOMMANDATION ADOPTED AT THE HELSINKI ASSEMBLY

International Association of Scientifi Hydrology

Resolution No. 1

Whereas the UNESCO in close coop ration with WMO is planning a symposiu to be held in Rome in 1961 on climatic chang with the following topics:

1) Criteria for the determination of climati fluctuation trends.
2) Data requirements for determining climati change.
3) Technique, e.g. radio-carbon dating, de drochronology, paleobotany, paleote perature, measurements, glacier fluctu tions, etc.
4) Theories of climatic change.
5) Salient facts of climatic fluctuations.
6) Implications of climatic changes fo geomorphology, soils and ecology plant and animals.
7) Future research.

It is resolved that the Internation association of Scientific Hydrology wishes t participate in this most important symposiu

Resolution No. 2

Whereas it is considered necessary t study the variations in existing glaciers.

it is resolved that the Internation

Scientifique soumet la Résolution qu'un ...oque sur la variation des Glaciers soit ... en 1962 à Obergürgl (Autriche).

Résolution n° 3

Considérant que l'Institut de Geophy-...e de Huancayo, organisme officiel du ...vernement Peruvien, propose qu'une ...férence Internationale sous le patronage ...mun de l'U.G.G.I., de l'U.R.S.I. et ...C.I.G. soit tenue au Pérou en 1961.

Considérant que le but de cette Confé-...e doit être d'examiner et de discuter des ...lémes de geophysique équatoriale et de ...nir l'occasion de définir les domaines ...vestigation geophysique pour lesquels ...ones équatoriales offrent des caractéristi-... spéciales pour les programmes expé-...ntaux.

Considérant que ces caractéristiques ...ent les possibilités d'un important travail ...ydrologie, en océanographie et en météo-...gie.

L'Association Internationale d'Hydro-...e Scientifique émet, par la présente Réso-...on, le désir de participer à cette impor-...e Conférence.

Résolution n° 4

Considérant qu'un Comité Spécial sur ...géologie des Isotopes, la géochimie, la ...ermination de l'âge et de la radioactivité ... Roches, de la Commission de Géochimie ...é constitué en vue d'examiner ses rapports ...c l'U.G.G.I.

L'Association Internationale d'Hydro-...ie Scientifique qui porte un intérêt aux ...vaux de ce Comité Spécial demande à être ...ue informée de l'activité du dit Comité.

Résolution n° 5

Considérant que le Comité National de ...odésie et Géophysique de l'U.R.S.S. a ...posé la création d'un Comité pour l'étude ... la Dynamique et la Morphologie du litto-... marin.

Considérant que l'Association Interna-...nale d'Hydrologie Scientifique ne s'est pas ...squ'à présent engagée dans l'étude de tels ...jets en dépit des nombreux avantages pou-...nt résulter de la connaissance de ces phéno-...ènes.

Association of Scientific Hydrology shall hold a symposium on variations in existing glaciers at Obergürgl in Austria during 1962.

Resolution No. 3

Whereas the Huancayo Geophysical Institute, an official organism of the Peruvian Government, proposes that an International Conference on Equatorial Geophysics to be held in Peru in 1961 under the cosponsorship of I.U.G.G., U.R.S.I., and C.I.G.

Whereas the objective of the Conference would be to revise and discuss problems in equatorial geophysics and to provide an opportunity to define areas of geophysical investigation for which the equatorial zones offer special characteristics for experimental programs.

Whereas these characteristics provide opportunity for important work in hydrology, oceanography and meteorology.

THEREFORE it is resolved that the International Association of Scientific hydrology wishes to participate in this most important conference.

Resolution No. 4

Whereas an Ad Hoc Committee on Isotope Geology, Geochemistry, Age Determinations and Radio-Activity of Rocks (CIGAR) of the Commission on Geochemistry has been established to consider its relationship with I.U.G.G.

It is resolved that the International Association of Scientific Hydrology has an interest in the work of the Ad Hoc Committee and requests to be kept informed of the proceedings of said Committee.

Resolution No. 5

Whereas the Soviet National Committee of Geodesy and Geophysics has proposed the creation of a Committee for the Study of the Dynamics and Morphology of the Marine Littorals.

Whereas the International Association of Scientific Hydrology has not hither to been involved in studies of the above subjects despite the many advantages to be gained from a knowledge of these phenomena.

L'A.I.H.S. demande dans le cas où serait constitué dans l'U.G.G.I. un Comité chargé de l'étude de ces problèmes scientifiques, à participer aux travaux du dit Comité.

Résolution n° 6

Considérant que l'Academie des Sciences de l'Australie et le C.S.I.R.O. préparent une Conférence Internationale sur la Physique des Nuages, qui sera dirigée par la Division de Radio-physique du C.S.I.R.O. et se tiendra en Australie en septembre 1961.

Considérant que les organisateurs de cette Conférence ont exprimé le voeu que la Conférence soit tenue sous les auspices de l'U.G.G.I.

L'Association Internationale d'Hydrologie Scientifique, qui a une Commission des Précipitations, très interessée par cette question, demande à participer à cette Conférence, si l'U.G.G.I. donne son approbation.

Recommandation 7

L'Association Internationale d'Hydrologie Scientifique marque son intérêt pour une collaboration avec le Comité des Marées Terrestres pour l'étude de la question des fluctuations du niveau de certains puits sous l'action des mouvements de l'écorce terrestre.

Recommandation 8

L'Association Internationale d'Hydrologie Scientifique décide d'établir un Comité qui reprendra notamment le travail de son Comité des instruments mais étendra son action à tout le domaine de l'Hydrométrie. L'association offre la collaboration de ce Comité à la Commission d'Hydrométéorologie de l'Organisation Météorologique Mondiale. Commission d'Hydrométéorologie de diale.

La même offre est étendue à l'action du Comité de Standardisation de l'AIHS.

It is resolved that in the event a Com tee is established in I.U.G.G. to investi these scientific matters, the Internatio Association of Scientific Hydrology whi to participate in its work.

Resolution No. 6

Whereas the Australian Academy Sciences and C.S.I.R.O. are sponso an International cloud Physics Confere to be conducted by the C.S.I.R.O. Divis of Radiophysics, to be held in Austr during September 1961.

Whereas the organizers of the confere have expressed the wish that the Confere will come under the auspices of I.U.G

It is resolved that inasmuch as the In national Association of Scientific Hydrol has a Commission on Precipitation and very much interested in this matter, Association wishes to participate in the C ference providing the I.U.G.G. approves such action.

Recommandation 7

The International Association of Sci tific Hydrology expresses its wish to co borate with the Committee of Terrestr Tides in studying the question of the fluct tions of water level in wells under the influen of movements of the earth's crust.

Recommandation 8

The International Association of Sci tific Hydrology resolves to establish a comm tee which, whilst pursuing in particular work hitherto of the Committee on Inst ments, will extend its activities over the wh field of Hydrometry. The Association off the collaboration of this committee to Commission for Hydrological Meteorolog the World Meteorological Organizati

The same offer is extended to the Co mittee on Standardization of the Associati

ANNEXE II

PROGRAMME D'AVENIR DES QUATRE GRANDES COMMISSIONS DE L'A.H.I

A. Commission des Eaux de Surface

L'eau est un élément indispensable à la vie. Sur le plan économique et humain, la cro

ce continue des besoins en eau exige l'emploi le plus judicieux des ressources naturelles, qui implique la connaissance la plus exacte possible des méthodes d'évaluation et des ressour- en vue d'une répartition équitable entre tous.

Les besoins en eau couvrent pratiquement la presque totalité des activités humaines : nentation, hygiène, irrigation, production d'énergie électrique, navigation intérieure, et is un angle un peu différent : protection contre les crues.

Dans de nombreuses régions du globe, et bientôt dans toutes, suivants les estimations les s récentes, les besoins arrivent au niveau des ressources, qu'il n'est pas concevable de gas- ler.

Le rôle des hydrologues consiste à déterminer l'importance de ces ressources et leur varia- ité dans le temps et dans l'espace.

Au sein de l'Association Internationale d'Hydrologie Scientifique, la Commission des ux de Surface a pour mission essentielle l'étude du cycle de l'eau sur le plan scientifique n de fournir une base solide aux techniciens chargés de la réalisation des ouvrages et améné- ments.

Pour cette étude la Commission procède au Contrôle hydrologique des bassins versants à l'analyse systématique des facteurs qui conditionnent les débits des fleuves et rivières. exploitation permanente d'un réseau de plus en plus étendu de station de jaugeage permet tenir à jour l'inventaire des ressources en eaux de surface et des possibilités d'alimentation s nappes souterraines.

Les question les plus particulièrement étudiées au cours des dernières sessions ont été :

— l'étude systématique des crues, de leurs causes et leur propagation en vue de permettre mise en œuvre des moyens propres à préserver les vies humaines et les biens.

— l'étude des bas débits et des sécheresses dont les conséquences peuvent, du moins en rtaines régions du globe, devenir très graves (disettes, famines);

— et entre ces extrêmes l'étude des débits moyens qui est également d'un intérêt primor- al pour régler au mieux les possibilités d'approvisionnement en eau des populations, l'irri- tion des cultures, et les besoins industriels.

Pour cet ensemble d'études la Commission des Eaux de Surface a constitué des Comités rmanents chargés de l'examen et de l'analyse de problèmes spéciaux, tels que l'évaporation et vapotranspiration, les précipitations, les instruments et méthodes de mesure, la standardi- tion et ces méthodes.

En plus, des Assemblées Générales triennales sont organisés des Symposia où se rassem- ent les spécialistes de ces divers domaines.

Au cours de ces rencontres les hydrologues de tous les pays du monde ont la possibilité confronter leurs méthodes d'études, et l'enseignement qu'ils tirent de cette confrontation ternationale est un élément essentiel de progrès dans la connaissance des ressources en eau u Globe.

B. Future programme of work of the commission of snow and ice

1. To hold symposia on special aspects of our field of study between each General Assem- ly.

A symposium on «The variations of the regime of existing glaciers» is to be held in Ober- urgl, Austria in Sept. 1962.

2. In the purpose of organising our work and preparing the papers for publication the ommission will be sub-divided into four parts:

1) Glaciers
2) Seasonal Snow Cover
3) Sea, River, Lake Ice
4) Ground Ice.

The purpose of these sub-divisions will be to interest workers in these subjects which do not

at present attend our meetings, so that everyone with interest in ice *on* the earth will be broug
together. Dr. De Quervain has been appointed to cover 2), Dr. Pounder 3), and Dr. Bender

3. Group 1)—glaciers—has set up a sub-committee to prepare a document setting out t measurements which should be made in all glaciated countries so as to record from time time the variations in the regime of existing glaciers, they are to recommend the methods collecting the records publishing them. The observations in the various countries will be org nised through the National correspondents of the Commission.

4. At a later stage a similar task will be undertaken to record the variations in sea cover. A world-wide similar task could be undertaken on seasonal snow cover and grou ice cover.

In this way the commission would eventually obtain a much more accurate estimate the leved ice content and its distribution as well as its variation from time to time.

C. Commission on Subterranean Waters (General programme)

Introduction

The Commission on Subterranean Waters aims at promoting the science and knowled of hydrogeology both from a purely scientific and from a practical point of view. In this co nection the following can be said.

Fresh water is the most indispensable element for the development of human life. T rapidly growing demand for it for domestic, agricultural and industrial purposes requires judicious and economic exploitation of the world's fresh-water resources.

Fresh water occurs as surface and as subterranean water, and part of it is present in t form of snow and ice. Surface and ground water together constitute the water resources which the development of human society has to be founded. Although the amounts of surfa water surpass by far the amounts of ground water, the latter are not of less importance f man. In arid and semi-arid regions, where surface water generally is absent or available duri short periods only, water supply has to rely mainly on the ground-water resources. But al in humid areas, ground water is becoming more and more important for water-supply purpos because of the increasing pollution of the surface waters. At the same time it becomes mo and more necessary to safeguard the ground water resources from the dangers pollution.

It is, therefore, of the utmost importance to develop efficient and reliable methods for t exploration, exploitation and conservation of the ground-water resources for water-supp purposes. The Commission on Subterranean Waters sees it as its first task to assist in the dev lopment of such methods and to further the theoretical and practical knowledge required f the object.

Apart from water supply, there are other important fields where ground water has to dealt with:

- land reclamation, drainage, irrigation;
- ground-water problems in connection with civil engineering;
- waste disposal;
- mining; etc.

Also here the Commission on Subterranean Waters aims at promoting the knowled and methods needed to deal with these problems.

Programme for the near future

With a view to the general aims as outlined above, the Commission on Subterrane Waters intends to pay special attention to the following items in the coming years.

— The fundamental theories of the movement of water through porous and fissured med

— Field methods for the collection of hydrogeological information (e.g. geophysi methods, use of tracers).

— Analytical and other methods for the investigation of various types of ground-water [sys]tems (including e.g. the use of analog models).

— Arid-zone hydrology.

— Methods of increasing the supply of usable water, including methods of artificial [rec]harge of the ground water and methods of conservation of ground water both from a quan[tita]tive and from a qualitative point of view.

— Salt-water encroachment and other phenomena connected to the simultaneous occur[ren]ce of salt and fresh ground water.

— Geochemistry.

— Standardization in hydrogeological work whereever it is useful, as in the collection, [ela]boration and registration of hydrogeological data; in the instruments used in field work; [in] the methods of making hydrogeological maps.

[Wo]rking methods

The Commission tries to fulfill its purposes through.

— the exchange of experience and knowledge at the meetings of the Commission during [the] General Assemblies of I.U.G.G.;

— the organisation of symposia on special subjects which are opportune at that moment;

— the initiating and promotion of special studies, if necessary through the formation of [spe]cial committees or subcommissions;

— the promotion of personal contacts between the hydrogeologists in the world;

— a close collaboration with the other commissions of the I.A.S.H. and with the other [as]sociations of the I.U.G.G.;

— a close collaboration with the other international organisations dealing directly or [in]directly with hydrogeology;

— the co-ordination of research and investigations, e.g. by promoting the collaboration [be]tween the different permanent services working in the field in question;

— collaboration in the publication of the hydrological bibliography of the I.A.S.H.;

— publication of the scientific papers presented at the meetings and of other papers or [re]ports considered of importance.

[D]. Commission de l'Erosion (Programme Général)

[I.] Agropédologie

1. Rapports de l'érosion du sol avec le [b]lan hydrologique: Pluie, ruissellement, infil[tr]ation, emmagasinement par le sol, évapo[tr]anspiration, percolation. Influence des autres [él]éments du climat.

2. Rapport de l'érosion du sol avec le [su]bstratum, les caractéristiques des sols : [s]tructure, texture, état physico-chimique, [ca]ractères mécaniques et hydrodynamiques, [p]orosité, perméabilité).

3. Rapport de l'érosion avec les prati[qu]es agricoles et l'application des divers [p]rocédés agrologiques et mécaniques de [co]nservation des sols. Effets de la couverture [v]égétale.

D. Commission of land Erosion (General Program)

I. *Agropédology*

1. Relations between soil erosion and hydrological balance : Rain—Runn-off, Infiltration—soil storage—evapotranspiration—precolation—other climatic elements.

2. Relation between soil erosion and substratium, soil caracteristics (structure, texture, mecanical and hydro-dynamical properties, porosity, permeability, etc.).

3. Relation between soil erosion and agriculture practices, and agricultural and mecanical means of soil conservation. Effects of vegetal cover.

4. Migrations des éléments du sol. Incidences agronomiques.

5. Cartographie des effets et des facteurs de l'érosion. Cartes d'aménagement et d'exploitation optimum.

6. Equipement des stations expérimentales, programmes de recherche, instruments de mesure, notamment : mesure de humidité dès sols, d'énergie cinétique de la pluie, appareils d'aspersion, essais mécaniques, physiques et chimiques.

II. *Hydrologie : cours d'eau et glaciers, circulations souterraines*

1. Erosion et transport des produits en solution ou non dissous (Débit de fond et en suspension) par les cours d'eau, les circulations karstiques et les glaciers actuels. Caractéristiques des matériaux transportés.

2. Erosion des berges, abrasion des bassins versants, glissements de terrain.

3. Dépôt de produits d'érosion dans les champs d'inondations, dans les lacs, dans la mer ou dans les dépôts glaciaires. Effets des barrages.

4. Prévision des transports insolubles ou en dissolution. Billan Physico-chimique. Matières minérales et organiques.

5. Relation des tonnages transportés avec :

a) — le climat : pluie (volume, énergie cinétique, agressivité). autres éléments du climat (température, rayonnement, évapotranspiration)

b) — le substratum géologique : lithologie, topographie

c) — l'érosion du sol : Agropédologie.

6. Instruments de mesures sur les cours d'eau, sur les barrages, etc.

III. *Géophysique*

1. Erosion et tectonique. En particulier tendances introduites par les mouvements actuels ou récents de la croûte terrestre, effets de l'érosion et de la sédimentation sur la tectonique.

2. Erosion et âge stratigraphique du substratum.

3. Eıosion et paléoclimatologie.

4. Morphologie des cours d'eau — stabilité des chenaux.

IV. *Erosion colienne*

4. Migration of soil elements—Agr nomic consequences.

5. Cartography of effects and factors erosion—Maps of optimum soil manageme and use.

6. Equipment of experimental statio programme of research, measurement instr ments, specially soil humidity, rain cine energy, sprincklers, mechanical, physical a chemicl tests.

II. *Hydrology, surface and underground w ters, glaciers*

1. Erosion and tranpiration of materi in solution insoluble (bed load and suspend load) by streams, underground circulatio and glaciers. Caracteristics of transport materials.

2. Bankerosion, abrasion, of watershe landsledes.

3. Deposition of erosion products flood plains, lakes, sea, or glacier therminals Effect of dams.

4. Prediction of transports, insolubl or soluble. Physico chemical balence—Mi ral and organic products.

5. Relation between transported wei and :

a) climatic : rain (volume, cinetic energ agressivity, intensity) other elements of climate temperature, radiation, ev potranspiration.

b) substratum : lithology—topogıaph

6. Instruments, measurement station streams, dams. etc.

III. *Geophysics*

1. Erosion and tectonics—special trends produced by recent or actual mouv ments of the earth crent. Effects of erosi and sedimentation on tectonics.

2. Erosion and stratigraphic age of fo mations.

3. Erosion and paleoclimatology.

4. Stream morphology—stability ofcha els.

A côté des ces grandes commissions, il faut noter les comités suivants :

mité des Précipitations

Rien n'est aussi mal connu que la répartition spatiale et temporaire des précipitations. Comité s'efforcera surtout d'acquérir une meilleure connaissance de cette répartition. A point de vue l'étude des appareils et des méthodes de mesure prend une importance de tout mier plan, mais l'étude des résultats, l'influence des divers éléments, comme l'altitude, le ime des vents, la pente, etc., la question des précipitations solides, celles des chutes occultes, . etc. présentent une multiplicité quasi sans fin de problèmes dont l'importance pour toutes applications de l'hydrologie est énorme. (Navigation, puissance motrice, irrigation, drainage nentation en eau, etc. etc.).

mité de l'évaporation et de l'évapotranspiration

Le programme publié plus loin n'est qu'une brève esquisse de l'étude de cette question i est peut-être le point primordial de l'hydrologie à l'heure actuelle quand la plus grande rtie de la surface du globe manque d'eau : la solution la plus aisée à cette disette généralisée st-elle pas une étude des pertes par évaporation.

mité de l'Hydrométrie

L'importance d'un tel comité saute aux yeux. Comme on le disait ci-dessus, la plus grande rtie de la surface du globe manque d'eau. Pour y porter remède, il faut pouvoir mesurer dont on dispose, mesurer aussi ce qui serait nécessaire.

En collaboration avec le Comité d'Hydrologie de l'O.M.M., notre Comité de l'hydro-étrie a devant lui un champ bien vaste à étudier.

Il en est de même du rôle du :

mité de Standardisation qui a partie liée avec le précédent.

mité des Cartes des Eaux Souterraines

L'eau souterraine reste la ressource la plus prisée de l'eau alimentaire. Des cartes donnant caractéristiques tant physiques que chimiques aussi bien que l'«abondance» et les possi-ités d'exploitation de ces eaux sont appelées à rendre les plus grands services aux utilisateurs une part, aux hommes de science d'autre part.

L'A.I.H.S. joue un rôle de pionnier dans ce domaine où son exposition d'Helsinki a été coup de maître.

ote sur l'Érosion glaciaire

Au congrès de Toronto, j'avais demandé à certains membres de la Commission Neige Glace s'il n'était pas intéressant de mettre à l'étude l'érosion glaciaire, comme cela est fait ur celle qui est causée par les eaux superficielles et souterraines. Cette suggestion n'avait s rencontré d'écho, les personalités consultés ayant été d'avis que ce phénomène était peu portant dans les conditions actuelles, à part des cas spéciaux.

Depuis Toronto, j'ai eu l'occasion de voir des cours d'eau glaciaires transportant une portante quantité de sédiments. D'autre part, M. Lanzen, dans le Bulletin N° 10 de l'As-ciation d'hydrologie de 1958 a donné les taux d'abrasion suivants pour deux cours d'eau s Alpes :

Bassin de Venter Ache, partie englacée, (46% du bassin)	3000t/km²
Lech, non englacée	35t/km²

Non seulement l'érosion du Venter Ache est énormement supérieure à celle du Lech, ais elle atteint les taux les plus élévés constatés dans des régions Mediterranéennes parti-ulièrement sujettes à l'érosion.

Cette observaton paraît être confirmée par les observations des ingénieurs qui ont eu à nstruire des prisies d'eau sous glaciaires.

D'autre part, M. Jevtayev, dans un rapport présenté à Helsinki évalue à 100t/km² envir l'abralsion par les glaciers de l'Antarctique. Il est vraisemblable que le régime de l'érosion p les inlandsis est assez différent de celui de l'érosion par les glaciers Alpins. Bien que M. Lanz ait procédé dans son étude référencée à une extrapolation du Venter Ache à l'ancien inlands Alpin.

Cependant toutes ces observations concourent pour mettre en question l'érosion glaciai et pour soulever ce problème de nouveau à la Commission Neige et Glace, à qui devraie être soumises en particulier les suggestions suivantes :

1. Dans toutes les études sur les glaciers actuels, faire l'évaluation de l'abrasion, du transport des produits d'abrasion par les cours d'eau sous glaciaires, et par les glacie eux-mêmes.

2. Si la Commission Neige et Glace décidait de sélectionner pour ses travaux futurs d sujets d'études particuliers, celui de l'érosion glaciaire ne mériterait-il pas un ordre urgent rapport avec son importance apparente?

d) Assemblee generale du 26 juillet 1960 à 14 30 h

Cette Assemblée fut particulièrement consacrée à la présentation de l'Adresse Préside tielle de Monsieur WILM et à celle du Rapport du Secrétaire.

Ces deux documents ont été publiés dans le bulletin N° 18.

Après la présentation du rapport, le Président Monsieur WILM remercie le Secrétaire sa famille pour le travail qu'ils ont fourni et le développement qu'ils ont donné à l'Associatio Il présente alors à l'Assemblée la liste du Comité des Nominations : MM. SCHOELLER, QUERVAIN, AVSIUK ainsi que celle du Comité chargé d'étudier s'il faut créer une Associati de Glaciologie : Messieurs WILM, TISON, AVSIUK, SCHUMSKY, FINSTERWALDER, WARD.

Le Secrétaire remercie particulièrement les représentants de l'UNESCO et de l'O.M.M

e) Assemblee générale du 5 aout 1960 à 14 h 30

List of attendance

A. VOLKER	HOLLAND	H. SCHOELLER	FRANCE
L. SERRA	FRANCE	J. RODIER	FRANCE
G. MORANDINI	ITALIA	M. MANSELL-MOULLIN	U.K
G. ALIVERTI	ITALIA	C.L. WALKER	U.S.A.
S. SCHMORAK	ISRAEL	R. LEBRICHT	U.S.A.
M. GOLDSCHMIDT	ISRAEL	J.V. SUTCLIFFE	U.K.
S. MANDEL	ISRAEL	SAGHAYROON EL ZEIN	SUDAN
W. FRIEDRICH	GERMANY	H. SIMOJAKI	FINLAND
C.C. WALLEN	SWEDEN	N. KOROLEFF	FINLAND
G.E. HARBECK JR.	U.S.A.	A. SIREN	FINLAND
O. LEPPANEN	U.S.A.	R.H. CLARK	CANADA
A.S. BRUGGEMAN	HOLLAND	J.P. BRUCE	CANADA
I. LUNDAGER JENSEN	DENMARK	P. KASSER	SUISSE
FRODE EBERT	DENMARK	P.O. WOLF	U.K.
H. VAN WIJNGAARDEN	HOLLAND	J.E. NASH	U.K.
G. SANTING	NETHERLANDS	T. O' DONNELL	U.K.
W. KRUL	NETHERLANDS	VÖLK	GERMANY
G.B. MAXEY	U.S.A.	D. DIACONU	R.P. ROUMAN
W.H. DURUM	U.S.A.	V. DIMITRESCU	R.P. ROUMAN
LOPEZ DE AZCONA	ESPANA	V.I. KACHOUK	U.S.S.R.
CH. SAFADI	U.A.R.	K. SZESZATY	HUNGARY

Bogomolov	U.S.S.R.	A. Dolgougchine	U.S.S.R.
Popov	U.S.S.R.	P.A. Shumsky	U.S.S.R.
M. Augewo	Finland	J.Z. Zumberge	U.S.A.
ton Jackhelln	Norway	W.O. Field	U.S.A.
N. Wilson	U.S.A.	H. Schubert	Germany D.R.
A. Kohler	U.S.A.	K. Stelczer	Hungary
B. Langbein	U.S.A.	K. Ubell	Hungary
F. Snyder	U.S.A.	R. Sneyers	Belgique
Avsiuk	U.S.S.R.		

dre du jour :

Elections et transmission des pouvoirs.
Résolutions et Recommandations.
Neiges et Glaces.
Publications futures.
Bulletin.
Colloques envisagés.
Hydrométrie et Instruments.
Cartes des Eaux Souterraines.

1. La liste des nouveaux dirigeants de l'Association et de ses Commissions telle qu'elle adoptée par le Conseil en sa séance du 4 août est présentée. Aucune objection. Monsieur ilm prend la parole. Il dit les mérites du nouveau président et lui souhaite un triennat fécond. onsieur Wilm remercie les membres de l'Association de leur collaboration si effective. Il dresse particulièrement au Secrétaire et à sa famille dont il loue le travail continu.

Monsieur Friedrich remercie et fera son possible pour maintenir l'A.I.H.S. au niveau l'ont portée ses prédécesseurs.

2. Le Secrétaire présente les résolutions et recommandations.. Aucune Objection.

3. Il donne également lecture de la conclusion des travaux du Comité pour les Neiges Glaces conclusion admise par le Conseil et reprise dans le Compte-rendu de sa réunion du août.

4. Il fait aussi part de la nouvelle décision relative aux publications futures (voir la même union du Conseil).

5. Il donne connaissance de la décision du Conseil au sujet du bulletin.

6. Il signale les divers colloques envisagés pour 1961 et 1962 (voir Conseil).

7. Il fait part de la disparition du Comité des Instruments et la naissance du Comité Hydrométrie.

8. Il porte brièvement à la connaissance de l'Assemblée les conclusions du Comité des artes des Eaux Souterraines (voir publication 52 de l'A.I.H.S.).

La séance est levée à 19h.

Colloque d'Athènes sur les Ressources en Eaux Souterraines en mettant l'accent sur les Zones Arides.

(En collaboration avec l'UNESCO)

Les pourparlers avec les autorités grecques responsables continuent. A la demande e l'Unesco, la date de l'ouverture du col-

2. Symposium at Athens (Grecce) on Groundwater Resources, with particular reference to Arid Zones

(in collaboration with UNESCO)

Negotiations with the responsible Greek authorities continue. At the request of Unesco, the opening date of the symposium

loque a été fixée au 12 octobre 1961. De cette façon bon nombre de personnes participant à la réunion du Comité des Zones Arides et au Colloque sur les Changements Climatiques qui se tiennent tous deux à Rome au début d'octobre pourront participer au Colloque d'Athènes sans trop de difficultés.

Le Secrétaire enverra une circulaire dès qu'il aura reçu des précisions des autorités grecques.

Au 1er février, une quarantaine de communications avaient été annoncées. Certains pays ont demandé un délai pour la présentation des titres et résumés.

Une première esquisse du programme pourrait être la suivante, mais il faut s'attendre à ce qu'elle soit modifiée :

mercredi	11 octobre 1961	
14 h 1/2		Séance d'ouverture
jeudi	12 octobre 1961	
9 h		Séance de travail.
jeudi	12 octobre 1961	
14 h 1/2		Séance de travail.
vendredi	13 octobre 1961	
9 h		Séance de travail.
vendredi	13 octobre 1961	
14 h 1/2		Séance de travail.
samedi	14 octobre 1961	
9 h		Séance de travail.
samedi	14 octobre 1961	
14 h 1/2		Réservé à des visites ou excursions.
dimanche	15 octobre 1961	
		Excursion.
lundi	16 octobre 1961	
9 h		Séance de travail.
lundi	16 octobre 1961	
14 h 1/2		Séance de travail.
mardi	17 octobre 1961	
9 h		Séance de travail.
mardi	17 octobre 1961	
14 h 1/2		Réservé à des visites ou excursions.
mercredi	18 octobre 1961	
9 h		Séance de travail.
mercredi	18 octobre 1961	
après-midi		Séance de clôture
jeudi	19	Excursions.
vendredi	20	Excursions.

has been fixed as the 12th October 196 It will thus become possible for a good num ber of those who attend the meeting of t Arid Zones Committee or the Symposiu on Climatic Changes, both in early Octob at Rome, to attend the Athens symposiu without much difficulty.

The Secretary will issue a circular soon as he has precise information from t Greek authorities.

By the 1st. February, news of some fo papers had been received. Some countri have asked for a delay in supplying titl and summaries.

A first outline of the programme cou be the following, but one must expect th it may be modified:

Wed.	11 October 1961	
14 1/2 hr		Opening session.
Thurs.	12 October 1961	
9 hr		Working session
Thurs.	12 October 1961	
14 1/2 hr		Working session
Fri.	13 October 1961	
9 hr		Working session
Fri.	13 October 1961	
14 1/2 hr		Working session
Sat.	14 October 1961	
9 hr		Working session
Sat.	14 October 1961	
14 1/2 hr		Visits or excursions
Sun.	15 October 1961	
		Excursion
Mon.	16 October 1961	
9 hr		Working session
Mon.	16 October 1961	
14 1/2 hr		Working session
Tues.	17 October 1961	
9 hr		Working session
Tues.	17 October 1961	
14 1/2 hr		Visits or excursions
Wed.	18 October 1961	
9 hr		Working session
Wed.	18 October 1961	
afternoon		Closing session
Thurs.	19 October 1961	
		Excursions
Fri.	20 October 1961	
		Excursions.

3) COLLOQUE SUR L'ÉROSION CONTINENTALE EN 1952

1. Ce colloque est organisé par notre Association. Nous n'avons jusqu'à présent aucun upport financier.
2. Le programme est le suivant :
    1) Sujets de communications libres, particulièrement : morphologie fluviale, transports solides, érosion du sol.
    2) Exposition portant sur la cartographie des effets et des facteurs de l'érosion du sol, utilisation de la photographie aérienne.
    3) Exposition d'instruments d'étude : matériel d'aspersion artificielle — humidité du sol — mesure des débits solides de fond et en suspension — énergie cinétique de la pluie, etc. ...
    4) Visite des stations d'étude et des régions les plus sujettes à l'érosion, en particulier les Apennins et l'Italie méridionale.
3. La réunion aura lieu en Italie, à Bari, en octobre 1962.
4. L'organisateur sera le Professeur Tison avec l'aide d'un comité Italien.

) SYMPOSIUM ON THE VARIATIONS OF THE REGIME OF EXISTING GLACIERS

Obergurgl, September 1962
First Circular

At the General Assembly of the I.U.G.G. at Helsinki in 1960 it was agreed that the ommission of Snow & Ice should hold a symposium entitled 'The variations of the regime f existing glaciers' at Obergurgl in the Austrian Tyrol in 1962. At the same time the Commis- on appointed a sub-committee to prepare a document detailing the methods of recording acier variations with the object of encouraging all countries to cooperate in a continuous & stematic world-wide assessment of the state & trend of glaciation. This sub-committee is ow at work, and it is hoped that its recommendations will be circulated to all nations and aat the measurements will be commenced before the Symposium takes place. The object of e Symposium is firstly to bring together all those people who are, and will be, engaged in gularly recording glacier variations to discuss their problems and to report progress, and condly to discuss recent research into the causes of glacier variations and the processes y which glaciers respond to climatic changes.

lace & date

The Symposium will be held from Monday 10th to Tuesday 18th September 1962 at bergurgl, Austria, by kind invitation of Prof. H. Hoinkes of the Institute of Meteorology & eophysics of the University of Innsbruck. Obergurgl is a high alpine village (altitude 6,300 et) lying at the head of the Oetztal, a valley which runs up to the Italian frontier to the south- ast of Innsbruck.

The meetings will be held in the Hotel Edelweiss & Obergurgl with a seating capacity of ore than 200 and with facilities for the projection of slides & 16mm film.

ccommodation

Details of accommodation, prices and booking instructions will be given in the next rcular. There is room for over 500 people in hotels, and in addition there is plenty of cheaper ccommodation in pensions and the State recreation centre.

Excursions

a) Before the Symposium. It is proposed that an excursion to several important Swis glaciers and research centres should be organised to commence about one week before th Symposium starts. This is intended mainly for the benefit of visitors from outside Europe Details will be sent later to those people who express a wish to join the excursion on the attache form.

b) During the Symposium. Several half & whole day excursions by bus, chair lift, and o foot will be arranged in fine weather during the period of the Symposium. These include visi to glaciers & other interesting places in the Oetztal, to the northernmost glacier in the Alp on the Zugspitz in Germany, to Meran in the South Tyrol (Italy), and to the Engadine in Zwitzer land. (Passports & visas will be required where necessary).

c) After the Symposium. Two excursions will be arranged to last 2 or 3 days after th Symposium is over:

1) by bus to the Pasterze glacier and the Gross Glockner, the largest glacier & the highe mountain in Austria.

2) on foot. A mountaineering trip to the Hintereis, Kesselwand

Kesselwand and Vernagt glaciers where the Austrian I.G.Y. programme on glaci meteorology was carried out. This trip will be led by Prof. H. Hoinkes and the party wi stay 2 nights in a mountain hut.

Banquet

A banquet, with entertainment by Tyrolese singers & dancers, will be given at the inv tation of the Tiroler Landes-Regierung representing the Austrian Government in the Tyro

Papers for the Symposium

a) Contents. The papers submitted to the Symposium must be original & must not hav been published previously. The papers can cover any of the following topics; reviews & analyse of records of the glacier variations & associated phenomena in any area, statements of ne national programmes for recording glacier variations, new data on detailed measurements o changes in the state of particular glaciers & correlation with climatic changes, studies of th processes & mechanisms by which glaciers vary in extent, theoretical studies of the respon of glaciers to seasonal & climatic changes.

The papers must relate to studies on *existing* glaciers; extinct glaciers & glaciations a excluded.

b) Text, diagrams & photographs. The complete paper, including short abstracts in bot English & French, diagrams, tables and photographs must not exceed 15 pages of print, eac page containing not more than 300 words. The paper must be written in either English o French. The number of photographs must be kept to a minimum: the diagrams must be draw with black lines on white paper, or tracing linen, and be suitable for direct reproductio Papers must be typed with double spaces between lines.

c) Limitation and screening of papers. Following the resolutions made at Helsinki, th number of papers to be submitted from each country to the Symposium is to be limited, an the suitability and quality of the papers are to be screened by a sub-committee appointed b the Commission. The commission has decided that the total number of papers which can b accepted is 40, and that the maximum number of papers from each member country is to b as follows :

U.S.A., and U.S.S.R.	6 papers each
France, Germany, Gt. Britain	3 papers each
All other countries	2 papers each

d) Submission of papers. The National committees of Hydrology will be responsible f selecting the papers within their quotas and for fixing the dates when they require the abstrac and complete papers to be submitted to them. The National committees should forward th

cted documents to the Secretary of the Commission not later than the dates given below.
be documents will not be accepted.
Three copies of the titles & abstracts in both English & French must be sent to the Secre-
of the Commission not later than February 1, 1962.
Three copies of the complete paper, with diagrams & photographs for reproduction,
st be sent to the Secretary of the Commission (adress: 147, Rickmansworth Road, Watford,
ts. England) to arrive not later than 1st. April 1962.
e) *Authors addresses & reprints.* Authors should give their addresses on their papers and
ce orders for the number of reprints they require on submitting their papers. A charge will
made for all copies of the proceedings of the Symposium & for all reprints.

liminary information from participants

nyone who is likely to attend the Symposium, or to submit a paper, should complete the
ached form and send it to the Secretary of the Commission as soon as possible and not later
n 30th June 1961.

PROGRAMMES POUR L'ASSEMBLEE DE 1963

I. COMMISSION DES EAUX DE SURFACE

Programme d'Etudes pour l'Assemblée Générale de 1963

1. Etudes théoriques et méthodes pra-
ues de *prévision des apports* des cours d'eau
ur des échéances diverses (à l'exclusion
prévisions de crues).

2. *Sécheresses*

Le programme établi pour l'Assemblée
Helsinki est maintenu, c'est-à-dire :
— caractéristiques et causes des sécheresses;
— fréquence d'apparition.

3. *Bas débits*

Courbes de tarissement. Influence sur le
eau des nappes souterraines. Etudes des
teurs hydrogéologiques (en liaison avec
commission des Eaux Souterraines).

4. Etude de l'*irrégularité temporelle* des
urs d'eau. Caractéristiques numériques et
résentations graphiques. Causes de l'irré-
larité.

II. COMMISSION DES EAUX SOUTERRAINES

Programme pour l'assemblée Générale de 1963

1. Relations entre les eaux de surface et
eaux souterraines (avec la Commission
s Eaux de surface).

5) TOPICS FOR THE GENERAL ASSEMBLY OF 1963

I. COMMISSION OF SURFACE WATERS

Questions for 1963

1. Theoretical studies and practical methods of forecasting the yield of rivers for both long and short terms (except floods).

2. *Droughts*

The same program as for the Helsinki meeting will be adopted, i.e.:
— characteristics and causes of droughts
— frequency of occurrences.

3. *Low discharges*

Depletion curves. Effects on the ground-water regime. Determination of the hydro-geological factors (Joint session with the Commission of Subterranean Waters).

4. *Variability in time* of river flow. Numerical characteristics and graphical representation. Causes of variability.

II. COMMISSION ON SUBTERRANEAN WATERS

Questions for 1963

1. Surface-and ground-water relationships. (A request will be made to the Commission on Surface Water to join us in discussing this subject).

2. Mouvement de l'eau dans des sols hétérogènes.

3. Chimie des eaux souterraines.

4. Méthodes pour le contrôle du régime des eaux souterraines; exploitation et conservation.

III. Commission de l'Erosion

Programme pour l'Assemblée Générale de 1963

1. Migration des éléments chimiques en suspension et en solution.

2. Evaluation des effets des pratiques agricoles et des pratiques de conservation des sols sur l'érosion.

3. Influence du changement de la structure du sol sur le Bilan d'eau et sur l'érosion (infiltration—évapotranspiration).

4. Transports solides.

IV. Commissions des Neiges et des Glaces

Sujets Libres.

V. Comite de l'Evaporation

Programme pour 1963

1. L'emploi de films monomoléculaires pour réduire l'évaporation et l'évapotranspiration comprenant l'effet du film sur la répartition des températures d'un réservoir.

2. Différences entre l'évapotranspiration potentielle et réelle pour différents types de végétation et de conditions d'humidité du sol.

3. Evaporation de la couverture neigeuse (en liaison avec la Commission des Neiges et Glaces).

4. Dispositifs pour mesurer l'évaporation et l'évapotranspiration.

5. L'influence de l'altitude sur l'évaporation.

6. Méthodes de mesure directe du flux de vapeur d'eau.

7. Variations saisonnières des coefficients pour différents types de bacs évaporatoires.

8. Méthodes pour déterminer l'évapotranspiration de grandes surfaces et relations entre l'évapotranspiration de grandes surfaces et de surfaces échantillons.

2. Movement of water in heterogeneo aquifers.

3. Geochemistry of ground water.

4. Methods for controlling the groun water regime; exploitation and conservatio

III. Commission of land erosion

Questions for 1963

1. Migration of chemical elements suspension or in solution.

2. Evaluation of effect of agricultu practices and conservation practices on e sion.

3. Influence of soil structure on t hydraulic balance and on land erosion. In tration — évapotranspiration.

4. Movement of sediments.

IV. Commission of Snow and Ice

Free Subjects.

V. Committee on Evaporation

Suggested topics for 1963

1.The use of monomolecular films reduce evaporation and evapotranspiratio including the effect of the film on the therm structure of a reservoir.

2. Differences between actual and pote tial evapotranspiration for various kinds vegetation and for various soil-moistu conditions.

3. Evaporation from snow (jointly w the Commission on Snow and Ice).

4. Equipment for measuring evaporati and evapotranspiration.

5. The effect of altitude upon evapo tion.

6. Methods of direct measurement vapour flux.

7. Seasonal variation in coefficients various types of evaporation pans.

8. Techniques for estimating evapotra piration losses from large areas and relatio between evapotranspiration from large ar and from sample areas.

VI. Comité des précipitations

Programme d'étude pour l'Assemblée de 1963

Variabilité des précipitations

— Répartition dans l'espace. Etudes particulières des facteurs influençant cette répar-on (conditions locales, situations météorologiques) et généralisation.

— Extension sur le terrain des précipitations de divers types. Application au choix du eau optimum de pluviomètres pour la détermination d'une précipitation sur un bassin.

— Représentation graphique de la variabilité des précipitations. Essai d'établissement «cartes de variabilité» complétant les cartes habituelles de précipitations moyennes.

Mesures spéciales

— Mesure des précipitations par radar et comparaison avec les méthodes classiques.

— Mesure des précipitations sur les surfaces d'eau étendues (grands lacs, à l'exclusion s mers et océans).

— Mesure des condensations occultes (rosée — brouillard). Evaluation de leur impor-nce par rapport aux précipitations courantes.

6) BRITISH NATIONAL COMMITTEE FOR GEODESY AND GEOPHYSICS

REPORT ON HYDROLOGICAL ACTIVITY IN THE UNITED KINGDOM

FFACE

To assist the work of the Hydrology Sub-Committee of the National Committee for eodesy and Geophysics, its National Correspondents were asked to report on hydrological tivity in the United Kingdom. This task was shared by Corresponding Members of three ommissions of the International Association of Scientific Hydrology — Professor G. Manley now and Ice), Mr W. Allard (Surface Water) and Dr S. Buchan (Ground Water) — and of ree of its committees — Mr A. Bleasdale (Precipitation), Mr. C.F. Lapworth (Evaporation) d Mr F.H. Allen (Instrumentation). On completion of the report, which follows, its publi-tion was recommended by the Hydrology Sub-Committee, to help satisfy many enquiries, ising both within this country and abroad, about recent and current hydrological activity the United Kingdom.

The National Correspondents acknowledge their indebtedness to Directors and Heads Research Departments for information on which are based the short accounts dealing with e main responsibilities, particular hydrological interests and research activities, of the various encies.

The Hydrology Sub-Committee wishes to record its appreciation of the work of the ational Correspondents and in particular to acknowledge its indebtedness to Dr S. Buchan o accepted the main responsibility for the compilation of this National Report.

Organisations with committees interested in research into scientific hydrology

ir Ministry: Meteorological Research Committee:
Sub-Committee II-Synoptic, Dynamical and Climatological

cretary: c/o Meteorological Research Committee, Meteorological Office, M.O. 15,
Victory House, Kingsway, London, W.C. 2.

British Glaciological Society: Executive Committee:
Research Sub-Committee
Secretary: Mrs H. Richardson, c/o Scott Polar Research Institute, Lensfield Road, Cambridge.

British Standards Institution: Flow Mesurement Committee:
Flow Measurement in Open Channels Sub-Committee
Secretary: A.S. Manklow, British Standards Institution, 2 Park Street, London, W. 1.

Department of Scientific and Industrial Research and Ministry of Housing and Local Gover-ment:
a) Joint Committee on Rainfall and Run-off
Secretary: L.H. Watkins, Road Research Laboratory, Harmondsworth, West Drayto Middlesex.
b) Informal Interdepartmental Scientific Working Group on Hydrological Researc
Secretary: L.L. Fox, Department of Scientific and Industrial Research, Charles Hou 5/11 Regent Street, London, S.W. 1.

Institution of Civil Engineers: Research Committee:
a) Rainfall and Run-off Sub-Committee
b) Hydraulics of Sewerage and Sewage Disposal Sub-Committee
Secretary: A. McDonald, Institution of Civil Engineers, Great George Street, London, S.W. 1.

Institution of Water Engineers:
a) Hydrological Research Group
Secretary: G.M. Swales, The East Surrey Water Company, Redhill, Surrey.
b) Evaporation Sub-Committee
Chairman: C.F. Lapworth, 25 Victoria Street, Westminster, London, S.W. 1.

Minister for Science: Natural Resources (Technical) Committee:
Sub-Committee on Agriculture: Irrigation Study Group
Secretary: D.L. Simms, Office of the Minister for Science, 2 Richmond Terrace, Whitehall, London, S.W. 1.

Ministry of Agriculture, Fisheries and Food: Agricultural Improvement Council: La Management Committee:
Field Drainage, Water Supplies and Other Services Sub-Committee
Secretary: L.D.G. Richings, Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W

Ministry of Housing and Local Government: Central Advisory Water Committee:
a) Sub-Committee on Growing Demand for Water
b) Sub-Committee on Information on Water Resources
Secretary: Miss M.E. Petzsche, Ministry of Housing and Local Government, Whitehall, London, S.W. 1.

Royal Scottish Geographical Society: River Flows Studies Committee
Convenor: Dr R.M. Gorrie, 15 Murrayfield Drive, Edinburgh, 12.

Royal Society: National Committee for Geodesy and Geophysics:
Hydrology Sub-Committee
Secretary: Dr D.C. Martin, Royal Society, Burlington House, London, W. 1.

Royal Society: National Committee on Antarctic Research
Secretary: Dr D.C. Martin, Royal Society, Burlington House, London, W. 1.

PRINCIPAL SOCIETIES AND INSTITUTIONS PROVIDING A FOCUS FOR DISCUSSION AND A JOURNAL FOR PUBLICATION OF THE RESULTS OF HYDROLOGICAL RESEARCH

ish Association for the Advancement of Science, 18 Adam Street, London, W.C. 2.
ish Glaciological Society, c/o Scott Polar Research Institute, Lensfield Road, Cambridge.
ish Society of Soil Science:
Honorary Secretary: D.V. Crawford, University of Nottingham School of Agriculture, Sutton Bonington, Loughborough, Leicestershire.
tish Waterworks Association, 34 Park Street, London, W. 1.
ve Research Group of Great Britain, Seaton House, Shrublands Road, Berkhamsted, Hertfordshire.
titute of British Geographers:
norary Secretary: Professor A.E. Smailes, Queen Mary College, Mile End Road, London, E. 1.
titution of Civil Engineers, Great George Street, Westminster, London, S.W. 1.
titution of Public Health Engineers, 179 Vauxhall Bridge Road, London, S.W. 1.
titution of Water Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W. 1.
er Boards' Association:
Secretaries: Dyson Bell and Company, 15 Great College Street, London, S.W. 1.
yal Geographical Society, Kensington Gore, London, S.W. 7.
yal Institute of Public Health and Hygiene, 28 Portland Place, London, S.W. 1.
al Meteorological Society, 49 Cromwell Road, London, S.W. 7.
yal Scottish Geographical Society, Synod Hall, Castle Terrace, Edinburgh, 1.
yal Society, Burlington House, London, W. 1.
ciety for Water Treatment and Examination:
Honorary Secretary: A.W.H. McCanlis, 41 Carshalton Road, Sutton, Surrey.
ott Polar Research Institute, Lensfield Road, Cambridge.

LIST OF AGENCIES ENGAGED ON HYDROLOGICAL RESEARCH GOVERNMENT

miralty, Hydrographic Department, Whitehall, London, S.W. 1.

The Hydrographic Department of the Admiralty is charged with the duty of carrying out veys around the British Isles and British territories abroad, and in the open oceans. It also oduces charts to cover the whole world, for issue to the Royal and Merchant navies, and blishes the necessary sailing directions, tide tables, radio lists and light lists.

The Tidal Branch of the Hydrographic Department, because of its responsibility for tidal edictions, is concerned with the effect of river water on tidal heights in important estuaries d rivers. The National Flood Warning Organisation, Air Ministry, Dunstable, for which the drographer is responsible, is interested in the effect of river water on tidal heights in connexion th the assessment of probabilities of very high water levels being reached.

gricultural Research Council, Unit of Soil Physics,
School of Agriculture, Huntingdon Road, Cambridge.

The function of the Agricultural Research Council is to supervise and support Government-sponsored research work of agricultural significance in Great Britain.

The research work is done in (*a*) State-aided research institutes and institutes controlled the Council, (*b*) University and other departments outside the control of the Council but led by specific Council grants, (*c*) Research units staffed by the Agricultural Research Council, ually located in Universities and directed by a University staff member. In the last of these tegories is the Unit of Soil Physics.

The work of the Soil Physics Unit arose in the first place out of the consideration of problems of land drainage and has developed to cover the whole field of the movement of water soils and in the surface layers of the earth's crust.

Ministry of Agriculture, Fisheries and Food, Land Drainage,
Water Supply and Machinery Division, Great Westminster
House, Horseferry Road, London, S.W. 1.

The Ministry of Agriculture, Fisheries and Food gives grant-aid to River Boards and internal Drainage Boards towards the cost of improvement schemes for rivers and other water courses. This includes grants made in collaboration with the Surface Water Survey of the Ministry of Housing and Local Government for the construction and improvement of river gauges. The ministry also grane-aids schemes for (a) fiield drainage of land and (*b*) farm water supplies for the irrigation of agricultural crops.

Their Land Drainage, Water Supply and Machinery Division, which works in close co-operation with the Boards and the farmers, has, therefore, an interest in hydrological infor mation and knowledge relevant to these schemes although the Division is not in itself a research establishment.

Ministry of Agriculture, Northern Ireland, Forestry Division,
7 upper Queen Street, Belfast, 1, Northern Ireland.

The Ministry of Agriculture, Northern Ireland, was charged under the Forestry Act (Northern Ireland), 1953, with the responsibility for promoting the interests of forestry and the development of afforestation.

By the end of 1957 the Ministry had secured leases or assisted with planning of abou 3,100 acres (13 km^2) of land scheduled as catchment areas, but progress was to some extent delayed because of the possible adverse effect of afforestation on run-off. Experiments were therefore, carried out by the Forestry Division of the Ministry to find out the effects of affo restation on run-off in certain areas.

Air Ministry, Meteorological Office.
Meteorological Office (M.O. 3*b*), Headstone Drive, Harrow, Middlesex, and Meteoro logical Office, School of Agriculture, Cambridge.

The Meteorological Office, which is part of the Air Ministry, is responsible for providin a national meteorological service. Its functions include collection, distribution, and publicatio of meteorological information from all parts of the world, and research in meteorology an geophysics.

One of its sections at Harrow is concerned with precipitation (including rain, snow an hail) and hydrology with particular reference to the United Kingdom. There are a number o Meteorological Office Stations where measurements are made, but the vast majority com from voluntary observers, water supply undertakers, river boards and others. A researc unit at Cambridge studies the measurement of evaporation by aero-dynamical methods.

Problems under investigation include the accuracy of rainfall measurements, the assessmen of areal rainfall, the duration-intensity relationships of heavy rainfall, evaporation and wat balance, and the processing and presentation of data including the use of electronic computer

Colonial Office-Falkland Islands Dependencies Survey
Crown Agents for Oversea Governments and Administrations,
4 Millbank, London, S.W. 1.

The Falkland Islands Dependencies Survey is responsible for topographic and hydro graphic surveys of these territories and is concerned, therefore, with mapping the extent o the ice. The results of scientific investigations carried out at the bases operated by the Surve are co-ordinated and published.

The Governor of the Falkland Islands and its Dependencies is responsible to the Coloni Office for the work of the Survey.

Ministry of Housing and Local Government. Surface Water Survey.
Whitehall, London, S.W. 1.

The Ministry of Housing and Local Government is concerned with the conservation an

er use of water resources in England and Wales and particularly with the prevention of ution of those resources and the supply of water to communities.

The Ministry maintains a Surface Water Survey which, in conjunction with the Scottish e, collects, collates and publishes in a series of yearbooks a selection of hydrometric data ing to surface water resources and areal rainfalls. These records are obtained from or ugh the Scottish Departments of Agriculture and Fisheries, and Health, River Boards ngland and Wales, water supply undertakers, North of Scotland Hydro-Electric Board, th British Aluminium Company and others.

The Survey also collects information about hydrometric instruments and techniques for aid of the River Boards and others concerned, and aims at ensuring that the rainfall and off gauging activity in each River Board area shall be so planned that the combined schemes ultimately provide adequate national networks of rainfall and river gauging stations.

Nature Conservancy, 19 Belgrave Square, London, S.W. 1.

The primary interest of The Nature Conservancy is the conservation of plants and animals, as individual species and in communities. Climate is the chief determinant and in its arch work the Conservancy studies correlations between climate and land use (in the adest sense of the term). Water balance and water conservation are the most important cts of such study.

Current research includes observations of potential evaporation from grass, heather peat lands in a variety of régions. The relationship between potential evaporation and cipitation are being studied, and measurements are being made of flow rates from small hments with different types of vegetation cover.

lding Research Station,
Bucknalls Lane, Garston, Nr Watford, Hertfordshire.

The Building Research Station, one of the research organisations in the Department of ntific and Industrial Research, is concerned with the study of problems of building and ed branches of civil engineering. One of its groups deals with problems of foundations and mechanics, and consideration of the effect of ground water on the stability of foundations, avations and earthworks is included.

The study of ground-water flow calls for measurements of permeability both in the laboory and in the field. A technique of pore-water pressure measurement has been developed following the slow movement of water through impermeable soils.

ological Survey,
Exhibition Road, South Kensington, London, S.W. 7.

The Geological Survey of Great Britain, now a branch of the Department of Scientific Industrial Research, was founded in 1835 to make geological maps which would be of vice to science and industry. This is still its main function. These maps and their explanay memoirs are of fundamental scientific and economic importance in understanding the logy and in investigating the natural resources of Great Britain.

The Water Division of the Geological Survey is concerned with research into the occurice, storage, movement, quantity, chemical quality, abstraction and replenishment of ground ter. This involves collection of basic ground-water data, systematic regional surveys of the uifers, as well as fundamental and applied research.

e Laboratory of the Government Chemist,
Water Division, Dudley House, Endell Street, London, W.C. 2.

The Laboratory of the Government Chemist, now in the Department of Scientific and dustrial Research originated in the need of the Board of Customs and Excise for analytical vices in connexion wiht revenue duties. Since its establishment over 100 years ago the scope

of the work has widened and it now provides analytical and advisory services to most Gover-ment departments and several statutory bodies.

The Water Division is primarily concerned with the treatment of water for drinki purposes, for hot water installations and for steam raising; the examination of effluents fro sewage treatment plants and special investigations such as the fluoridation of public wa supplies, river surveys and the disposal of house refuse.

The principal contribution to hydrological research made by its Water Division is t study of the chemical character of rainfall, surface waters and ground waters.

Hydraulics Research Station,
Howbery Park, Wallingford, Berskhire.

The Hydraulics Research Station of the Department of Scientific and Industrial Resea is engaged on the investigation, often with the aid of models, of problems in open-chan hydraulics, such as the draining and control of rivers and estuaries, improvements to po and harbours, and coast protection. The programme includes both basic and ad hoc research

In hydrology, the Station's main task is to improve existing methods of flood hydrogra prediction and flood frequency analyses using unit hydrograph techniques. Some experimen work is also in progress to examine the importance of soil moisture deficiency in run-off p dictions.

Road Research Laboratory,
Harmondsworth, Middlesex.

The Road Research Laboratory forms part of the Department of Scientific and Industr Research. Its functions are to carry out research into problems that arise in designing, buildi maintaining and using the public highways.

The Laboratory, in collaboration with the Meteorological Office and the Hydrau Research Station, has been undertaking research into the relationship between rainfall a run-off as it affects the design of surface water sewers. It has also made studies of soil moistu and evaporation.

Water Pollution Research Laboratory,
Elder Way, Stevenage, Hertfordshire.

The Water Pollution Research Laboratory is a branch of the Department of Scienti and Industrial Research. Its research work includes the development or improvement processes for purifying sewage and industrial wastes and the study of the effects of polluti substances, of all kinds, on natural waters.

In the course of investigating the second of these sections of work, the Laboratory stud the movement of water, for example longitudinal or vertical mixing in freshwater streams a the more complex movements which occur in an estuary under tidal oscillation. From time time the Laboratory has carried out work to improve existing methods of measuring the flo of a stream, for example by the use of radioactive tracers.

Scottish Office,

Department of Agriculture and Fisheries for Scotland, St Andrew's House, Edinburgh,
Department of Health for Scotland, St Andrew's House, Edinburgh, 1.

The Department of Agriculture and Fisheries for Scotland measures the flow of cert rivers in Scotland and forwards the data to the Surface Water Survey of the Ministry of Housi and Local Government.

The Department of Health for Scotland collects any records of measurements of surfa water resources made by water undertakers and also forwards them to the Survey.

Yearbooks, published by the Ministry of Housing and Local Government and the Scott Office jointly, report the material thus obtained. However, there is not at present any statut obligation on either of the Scottish Departments, or on any other body, to measure ri discharges in Scotland for the information of the public.

vernment sponsored

eshwater Biological Association,
The Ferry House, Ambleside, Westmorland.

The Freshwater Biological Association, which is a private organisation sponsored by Development Commission, was founded in 1929 with the object of promoting research the problems of life in fresh and brackish waters.

Little work has been done so far on hydrology in its strict sense, but research has been dertaken on the water movements in lakes and on the chemistry of rain and natural waters.

e Grassland Research Institute,
Hurley, Near Maidenhead, Berkshire.

The primary function of the Grassland Research Institute, which is sponsored by the gricultural Research Council, is research on the management of grassland for herbage production, and on the utilisation of the herbage produced.

Research has been carried out on the irrigation of grassland with particular reference the relation between herbage production and soil moisture status. This work has not yet en published except for brief notes in the Annual Reports of the Institute from 1956 onwards.

itional Vegetable Research Station,
Wellesbourne, Warwickshire.

The National Vegetable Research Station is mainly concerned with research into methods improving the yield and quality of vegetables.

Its Irrigation Section is investigating the water requirements of vegetable crops with the ject of determining the extent to which it is necessary to supplement natural rainfall by igation to obtain the optimum economical yield and quality of produce and to make the st use of available supplies of water. The work involves determination of current soil moisture tus.

The relationship of the Penman estimate to measured loss from different vegetable crops being studied and compared with the loss from evaporation tanks, transpirometers and evarimeters.

The experiments on water requirement of crops carried out at Wellesbourne are supplented by larger field experiments at four horticultural stations (National Agricultural Adviry Service):-Efford in Hampshire, Luddington in Warwickshire, Rosewarne in Cornwall d Stockbridge House, Cawood, Selby, Yorkshire.

othamsted Experimental Station,
Harpenden, Hertfordshire.

Rothamsted Experimental Station is the largest and eldest of the agricultural research ntres controlled by the Agricultural Research Council. Most of the departments are biological, ing concerned with the plant in health and disease. Of the non-biological sections, the ysics Department divides its interest between the root environment (Soil Physics) and the af environment (Agricultural Meteorology).

Studies of soil water come into both spheres of interest, and within the past two decades ere has grown up a body of information and a number of ideas on the relationship between e use of water by plants and the climate in which the plants grow. From this a double interest hydrological problems has developed.

The immediate practical application has been to show the need for irrigation of farm ops in south-east England, and it has been an obvious step to examine the water balance of e country as a whole to see where the needed water might come from. At the same time this amination has been used as a test of the ideas, treating whole catchment areas as large evaporation gauges.

River Boards (England and Wales)

These Boards number thirty-two and, together with two other authorities, Thames Con-servancy and Lee Conservancy Catchment Board, cover the whole of England and Wales excepting part of the London area. The thirty-four authorities are concerned with land drainage, freshwater fisheries, prevention of river pollution and, in some cases, navigation.

They are required, by the River Boards Act, 1948, to measure systematically the rainfa and river flows in their respective areas. They also measure temperatures of river water at few points and obtain the relevant records of those water supply undertakers and others wh measure surface water resources.

The data accumulated by the Boards are forwarded to the Surface Water Survey of th Ministry of Housing and Local Government. Each Board also makes its own records availab to the public.

Research is being carried out by some of the engineers of the Boards, using the rainf and gauging records. Changes of ground-water storage are being measured in several drainag areas.

Water Supply Undertakers

The water supply undertakers are required to measure the amounts taken by them fo the need of communities rather than the total surface or underground water resources from which they derive their supplies. As regards residual surface water resources, the undertakers usually have to establish that a prescribed minumum flow has been left in the stream from whic abstraction has taken place.

There are, however, a few undertakers utilising surface water resources who voluntaril make additional measurements in order to determine over any period of time the amount o water draining from their catchments. In such cases the data obtained are supplied to th Ministry of Housing and Local Government in England and Wales through the local Rive Board and in Scotland through the Department of Health for Scotland.

Surface-water measurements relate in the main to upland areas and impounded stream and are usually effected by measuring structures (weirs, etc.) rather than by current meter

The undertakers who use ground-water resources send to the Geological Survey suc measurements of volumes of abstraction, water levels in their wells, and water quality as the are required to make.

The engineers of some of the undertakers have, as individuals, conducted hydrologica research.

Universities

Amoung the twenty-two universities there are many individual members in a variety o departments and disciplines who have been engaged in research in one branch or another o hydrology. Detailed reference to the work being carried out is made in the following sectio on research activities. In addition a number of unpublished projects on various hydrologica subjects have been undertaken by post graduate students of engineering hydrology who com to Imperial College from various countries.

Other Agencies

Cave Research Group of Great Britain,
Seaton House, Shrublands Road, Berkhamsted, Hertfordshire.

Exploratory surveys of caves are made by a number of clubs and societies. Thier wor includes making maps, taking photographic and other records and noting the flora and faun of the caves.

The Cave Research Group has included in its activities research into the direction and of movement of water underground, at home and abroad.

itution of Water Engineers: Hydrological Research Group: Evaporation Sub-Committee.

The scope of the Group is the study of hydrology, especially those branches relating to fall, run-off, percolation and evaporation, including (*a*) measurement of phenomena and interpretation of records and the appropriate use of statistical methods.

The Evaporation Sub-Committee, jointly with the Metropolitan Water Board, is collecting poration data at one of the Board's reservoirs.

tt Polar Research Institute,
Lensfield Road, Cambridge.

The Institute is the national and international centre for the encouragement of polar earch and exploration. It is now attached to the Department of Geography, University of mbridge. The Institute has undertaken research in many disciplines but in recent years cial emphasis has been placed on snow and ice studies.

The seasonal distribution of sea ice has been a major subject of research which has included urvey of recording and reporting methods.

ter Research Association,
18 Linkfield Lane, Redhill, Surrey.

The Water Research Association is one of a number of associations for co-operative earch set up to apply advances in science to the benfit of industry. It receives Governement nt through the Department of Scientific and Industrial Research.

Recently research has been carried out on problems of the coagulation process of water ification, acoustic methods of leak detection and the characteristics of plastic water pipes. e research programme is being expanded and will permit the inclusion of hydrological estigations.

vate individuals.

Hydrological research is being undertaken by a number of private individuals whose work referred to in the following section.

RESEARCH ACTIVITIES

ecipitation

Rainfall research is carried out mainly by, or in conjuction with, the Meteorological Office. udies by other Government Departments are largely dependent on data supplied by them

Research work on accuracy of standard measurements, including the use of rain-gauge ields and the experimental use of a compound rain gauge, is undertaken by the Meteorolocal Office in conjuction with the Fylde Water Board, Road Research Laboratory and National getable Research Station.

Measurement of rainfall in non-standard sites, for example above woodland canopy, is ing made by the Meteorological Office in conjuction with Fylde Water Board and the Department of Forestry, Oxford University. Precipitation over rugged terrain and on ships is now ing investigated.

The Meteorological Office is also engaged in the assessment of areal rainfall and in collecng and studying measurements of the amount, character and frequency of snowfall within e United Kingdom.

Research by the Meteorological Office is proceeding on the processing and presentation data, including the development of machine methods.

Intensity-duration frequency distributions of heavy falls of rain over the British Isles a also the subject of research by the Meteorological Office in conjunction with Road Resear Laboratory and local town drainage authorities.

The areal distribution of intense falls of rain are being investigated at Cardington by t Meteorological Office.

Measurement of rain falling on a conifer plantation is being made by the Fylde Wa Board (F. Law) in its Stocks Reservoir catchment, where particular attention is given to meas rements of rain reaching the ground, stem-flow down selected trees, and run-off from a ly meter.

Measurement of rainfall in the South Tyne river basin is the subject of research by t Geography Department of King's College, Newcastle-on-Tyne (J.I. Sharp) and in Upp Weardale by the Geography Department of Bedford College, London (Miss E.M. Shaw

Evaporation

A Meteorological Office unit at Cambridge (first Dr F. Pasquill, later N.E. Rider) h studied the aerodynamic aspect of the evaporation process, and has now a computer whi given a continuous record in the field of instantaneous evaporation rate over any kind of su face. A description of the instrument will be published during 1960.

At Rothamsted Experimental Station, the Physics Department (Dr H.L. Penman and I J.L. Monteith) has studied the energetic aspects of the evaporation process and the resu have been widely applied to agricultural problems, e.g. irrigation, and hydrological problem e.g. water balance of catchment areas.

A research group of the Institution of Water Engineers is collecting evaporation data ov a 40-acre (16 hectare) reservoir of the Metropolitan Water Board at Kempton Park togeth with some supplementary weather data and water temperatures.

Other records or estimates of evaporation, either for control or for information, are bei made by the Fylde Water Board (catchment evaporation), the Grassland Research Institu (irrigation control), the National Vegetable Research Station (irrigation control), and T Nature Conservancy (land management).

Evaporation in a conifer plantation has been studied by the Botany Department, Imperi College, London (Dr A.J. Rutter). The methods used; have included soil sampling, moistur indicating instruments in the soil and direct measurement of interception and evaporation fro the soil surface.

In the course of research on soil moisture, the Road Research Laboratory has measur evaporation from the soil for comparison with estimates made by Penman's method.

Surface Water

River flow measurements are made principally by the River Boards and by water supp undertakers, and these basic data are used extensively by research workers.

The Hydraulics Research Station is developing a method of determining certain par meters of the instantaneous unit hydrograph from records of rainfall and stream flow. Corr lations are being sought between the parameters and the characteristics of the drainage ar to which the unit hydrographs apply. Mr T. O'Donnell, Imperial College, has developed method of deriving the instantaneous unit hydrograph from excess rainfall and run-off curv by way of harmonic analyses.

The relationship between rainfall and run-off is being investigated by the Road Resear Laboratory in ten urban areas and in a natural drainage area of over 5,000 acres (21 km The Hydraulics Research Station and the Civil Engineering Department of Imperial Colle London (P.O. Wolf) are making similar investigations.

Mr F.V. Appleby is making fundamental studies of urban and natural stream networks sing from surface flow by means of a heat analogue instrument. Dr H.E. Hurst is studyig statistics of the variability of river flow.

Relationships between the size of a river basin, stream dimensions and discharge, with rticular reference to the South Midlands. Cotswolds and head-waters of the River Thames, ve been the subject of research by the Geography Department of Birkbeck College, London r G.H. Dury).

Measurements of stream flows in the South Tyne basin are being made by the Civil Engi-ering Department of King's College, Newcastle-on-Tyne.

The forecasting of floods in river basins has been the subject of research by River Boards rent River Board).

The effect of river water on tidal heights for flood forecasting is being studied by the ational Flood Warning Organisation, Dunstable.

Research on the effect of the River Thames on tidal heights has recently been carried out the Hydrographic Department of the Admiralty in conjuction with the Chief Engineer's epartment, London County Council. A brief reference to the results of this research will ppear in the Admiralty Tide Tables, vol. 1 for 1962.

Much of the hydrological work on snow and ice is concerned with phenomena occurring itside the United Kingdom. Considerable research in this field is however organised from is country and undertaken by its research workers.

Recent glaciological work in the Antarctic includes studies, relating to snow and ice accu-ulation, by the Falkland Islands Dependencies Survey, in particular work on the mass balance ice in South Georgia by the late J. Smith. Notable investigations include work on borehole ctions in firn by the British Trans-Antarctic Expedition. 1955-58, both at «South Ice» and iring the crossing of the continent.

Aspects of the behaviour of glaciers and the physics of ice have been studied by the Cam-idge Austerdalsbre Group on Austerdalsbreen in Norway during the period 1955-59. Much the work of this Group has been organised by W.H. Ward of the Building Research Station, ho is making a study of the physics of glacier flow. Valuable measurements have also en made by the Cambridge West Greenland Glaciological Expedition 1958 and other ivate expeditions who report their work back to the Glaciological Research Sub-Committee the British Glaciological Society.

Much of the glaciological work in the United Kingdom is carried out within the Uni-ersities, most of the active research workers being associated with the British Glaciological ociety and the Scott Polar Research Institute.

Individual research projects are listed below under the University concerned.

niversity	*Department*	*Research workers and projects*
irmingham	Physics	Dr J.W. Glen — Glacier deformation and flow (Member of Cambridge Austerdalsbre Group).
ristol	Physics	Dr J.F. Nye — Physics of the flow of ice (Member of Cambridge Auster-dalsbre Group).
ambridge	Geography	W.V. Lewis — Movement of a valley glacier (Member of Cambridge Austerdalsbre Group).

	Geography Scott Polar Research Institute	Dr G. de Q. Robin — Ice shelves an ice sheets in Greenland and th Antarctic. Dr T.E. Armstrong — Sea ice an terminology. G.R. Elliston — Observations on flo on Gornergletscher. Dr B.B. Roberts — Terminolog Dr C.W.M. Swithinbank — Antarcti glaciology.
Durham (King's College Newcastle-on-Tyne).	Geography (Polar Studies)	Dr H. Lister — Studies of mas balance, and drifted and fallin snow in Greenland and th Antarctic.
Hull	Geography	G. de Boer — Investigation on Auste dalsbre and Tunsbergdalsbr glaciers in Norway (Member o Cambridge Austerdalsbre Group
London (Bedford College)	Geography	Professor G. Manley — Late and pos glacial fluctuations in snow an ice cover.
(Imperial College)	Geology	D. Taylor Smith — Gravity and seism surveys to determine thickness o ice at Austerdalsbre, Norwa (Member of Cambridge, Auste dalsbre Group).
Nottingham	Geography	Miss C.A.M. King and associates – Studies of Icelandic and Norwegia glaciers (Member of Cambridg Austerdalsbre Group).
Oxford	Geography	The late M.F.W. Holland — Glacio logy in Greenland. Miss M.M. Sweeting — Glacier fluctu ation in Vestspitsbergen.
Wales (University College of Swansea).	Geography	Miss G.E. Groom — Glacial studi in Vestspitsbergen.

Soil Water

Physical problems relating to the movement and equilibrium of water in the soil hav been studied by the Unit of Soil Physics (Agricultural Research Council). Measurements hav been made of soil permeability in saturated and unsaturated soils.

Research on soil moisture is being undertaken by the National Vegetable Research Statio the Road Research Laboratory and the Building Research Station.

Ground Water

Ground water research is being effected mainly by the Geological Survey but a gre many measurements of water levels, well yields and chemical analyses are submitted to th Geological Survey by water undertakers, industrial and agricultural ground water users, we drillers and others.

Well surveys and regional surveys of ground water conditions in the Chalk, Triassic ...tones, Coal Measures and other aquifers have been made over extensive areas of England ... Wales to obtain basic data.

...rtificial recharge of aquifers (Dr S. Buchan), ground water flow in the vicinity of a pumped ... Dr J. Ineson) and the mapping of marker bands in the Chalk as an aid to the location of ...ures favourable for containing ground water (D.A. Gray) are among recent researches. ...tudies of ground water flow around a discharging well with particular reference to sand- ... have been made by the Civil Engineering Department of Sheffield University (Professor ... Boulton).

...ocal investigations into the direction and rate of flow of water in fissures in the Lowe... ...oniferous Limestone of north-west Derbyshire, using fluorescein as a tracer, have been ... by members of Derwent Valley Water Board in association with the Cave Research Group ... described by Dr T.D. Ford. The circulation of ground water in cave systems in Jamaica ...been studied by Miss M.M. Sweeting.

An analytical and model study, of a ground water lowering project at a construction site ...ingle near the sea, has been made by T. O'Donnell (Imperial College).

...r Balance

Studies of the effect of afforestation on the water balance are being made by Fylde Water ...d; Belfast Water Commissioners; Department of Forestry, Oxford; and Ministry of ...culture, Fisheries and Food, all in conjunction with the Meteorological Office. The effect ...nd management on the water balance is being investigated by The Nature Conservancy. The balance of infiltration, ground water storage and spring flow are the subject of research ...he Geological Survey who have made several regional studies in different geological for-...ons.

Water balance studies have also been made by the Geography departments of Cambridge ...V. Lewis) and of Aberystwyth (J.C. Rodda).

...mistry of Natural Waters

Some work has been done on the chemistry of rainfall by the Meteorological Office (see ...eorological Office Discussion in Meteorological Magazine, 1958, *87*, 108-115), by the Fresh-...er Biological Association which has published some of the results of its research, and by the ...oratory of the Government Chemist.

The chemistry of surface waters has been investigated locally by the Freshwater Biological ...ociation, the Laboratory of the Government Chemist and the Water Pollution Research ...oratory.

Research into variations in the chemical character of ground waters has been undertaken ... the Geological Survey.

...resentatives of the British National Committee, for:

Surface Water:	Mr W. Allard, 9, Flower Walk Guildford, Surrey.
Subterranean Water:	Dr S. Buchan, Geological Survey & Museum, Exhibition Road, London, S.W. 7.
Snow and Ice:	Professor G. Manley, Bedford College, Regent's Park, London, N.W. 1.
Land Erosion:	Dr S.H. Shaw, 64, Grays Inn Road, London, W.C. 1.
Evaporation:	Mr C. Lapworth Rodmell, School Lane, Gerrards Cross, Bucks.

f) Standardisation:	Mr P.O. Wolf, Department of Civil Engineering, Imperi College of Science & Technology, City & Guilds College, London, S.W. 7.
g) Instrumentation:	Mr F.H. Allen, M.A., M.I.C.E., Director, The Hydrauli Research Station, Howbery Park, Wallingford, Berks.
h) Precipitations:	Mr A. Bleasdale, Meteorological Office, Headstone Driv Harrow, Middlesex.

7) COMPOSITION DU COMITÉ NATIONAL ITALIEN POUR L'HYDROLOGIE

FROSINI prof. ing. Pietro, Presidente di Sezione del Consiglio Superiore dei Lavori Pubbli Ministero dei Lavori Pubblici, Roma—*Presidente*;

TONINI prof. Ing. Dino, Docente di Idrologia presso l'Università di Padova—Società Adriati di Elettricità, Venezia, San Tomà, Palazzo Balbi—*Vice-Presidente*;

ARREDI prof. ing. Filippo, Ordinario di Costruzioni Idrauliche nel-l'Università di Roma, V Eudossiana, 18 membro;

BONAFEDE dott. ing. Giovanni, Ispettore Principale, Ispettorato Regionale Forestale, Regg Calabria—membro;

CANALI dott. ing. Lamberto, Ingegnere Capo, Ufficio Idrografico del Po, Parma, Via Garibal 75—membro;

CAVAZZA dott. ing. Samuele, Ingegnere Direttore della Sezoine Idrografica del Genio Civ Catanzaro, Via Francesco Crispi, 10-D—membro;

DE MARCHI prof. Giulio, Ordinario di Idraulica nel Politecnico di Milano, Piazza Leonardo Vinci, 32—membro;

DI RICCO prof. ing. Guido, Ordinario di Idraulica nell'Università di Roma, Via Eudossian 18—membro;

FEA col. dott. Giorgio, Capo Divisione «Studi e Ricerche», Servizio Meteorologico, Ministe della Difesa Aeronautica, Roma (EUR)—membro;

GHERARDELLI prof. ing. Luigi, della Società Edison, Milano, Foro Bonaparte, 31—membr

MARCHETTI ing. dott. Giovanni, Ispettore Generale, Ministero dei Lavori Pubblici, Roma membro;

MORANDINI prof. Giuseppe, Ordinario di Geografia nell'Università di Padova, Palazzo d Bo—membro;

PASSERINI prof. Gino, Direttore dell'Istituto Sperimentale per lo studio e la difesa del suol Firenze, Borgo Pinti, 80—membro;

ROSSETTI dott. ing. Mario, Ispettore Generale, Magistrato del Po, Parma, Via Garibaldi, 75 membro;

VANNI prof. Manfredo, del Comitato Glaciologico Italiano, Torino, Via Accademia de Scienze, 5—membro;

ZORZI ing. Leopoldo, dell'Ente per lo sviluppo dell'irrigazione e trasformazione fondiar in Puglia e in Lucania, Bari—membro;

GAZZOLO dott. ing. Tomaso, Direttore del Servizio Idrografico Centrale, Ministero dei Lavo Pubblici, Roma—Segretario Tecnico;

MANGONI dott. Pasquale, della Segreteria Generale del CNR—Segretario amministrativo.

Moscou, le 13 Février 196

8) U.R.S.S. LE SECRÉTAIRE A REÇU DE M. BÉLOUSSOV, LA LETTRE SUIVANTE :

Moscou le 13 février 1961.

le Prof. Tison
crétaire Général de l'AIHS
rue des Ronces
ntbrugge
gium

n cher Professeur,

Le Comité National de Géodésie et de Géophysique approuve par la présente lettre la signation des personnes suivantes en titre des correspondants spéciaux sur la glaciologie :

G.A. Avsiuk — membre-correspondant de l'Académie des Sciences de l'URSS, correspondant national sur la glaciologie toute entière.

Prof. G.K. Touchinsky (Université de Moscou) — correspondant national sur l'étude saisonnière du recouvrement de neige et des avalanches de neige.

Dr. P.A. Gordienko (Institut de l'Arctique et de l'Antarctique, Léningrad) — correspondant national sur l'étude des glaces de mer, de lac et de rivière.

Prof. N.A. Gravé (Département de Sibérie de l'Académie des Sciences de l'URSS) — correspondant national sur l'étude des glaces souterraines.

Je vous prie de croire, mon cher Professeur, à l'expression de mes sentiments distingués.

V.V. Béloussov
Président, l'UGGI

9) U.S.A.

SECTION OF HYDROLOGY AMERICAN GEOPHYSICAL UNION

Revised Slate of Officers to hold office until June 30, 1961

esident: Walter B. Langbein
ce President: William C. Ackermann
cretary: Charles C. McDonald

Executive Committee:

y K. Linsley, Past President
illiam E. Hiatt, At Large
arry E. Schwarz, Program Chairman
alph N. Wilson, International Participation
or Nordenson, Publication Liaison
N. Sayre, Ex Officio
.E. Smith, Ex Officio

Research Committee Chairman:

anklin F. Snyder, Surface Water
ilip E. La Moreaux, Ground Water
Earl Harbeck, Evaporation & Transpiration

Calvin C. Warnick, Snow
Mark F. Meier, Glaciers
Floyd A. Huff, Precipitation
M. Gordon Wolman, Erosion & Sedimentation

U.S. HYDROLOGY INTERNATIONAL CORRESPONDING MEMBERS UNTIL JUNE 30, 1961

Secretary for International Participation
Mr. Ralph N. Wilson
Corps of Engineers
Civil Works
Office, Chief of Engineers
Washington 25, D.C.

Corresponding Member, IASH Commission on Snow and Ice
Dr. Mark F. Meier
U.S. Geological Survey
529 Perkins Building
Tacoma 2, Washington

Corresponding Member, IASH Commission on Subterranean Water
Mr. Philip E. LaMoreau
Chief, Ground Water Division
U.S. Geological Survey
Washington 25, D.C.

Corresponding Member, IASH Commission on Surface Water
Mr. Franklin F. Snyder
Corps of Engineers
Office, Chief of Engineers
Civil Works
Washington 25, D.C.

Corresponding Member, IASH Commission on Continental Erosion
Dr. M. Gordon Wolman
Department of Geography
Johns Hopkins University
Baltimore 18, Maryland

Corresponding Member, IASH Committee on Precipitation
Mr. Floyd A. Huff
Illinois State Water Survey
Urbana, Illinois

Corresponding Member, IASH Committee on Evaporation
Mr. G. Earl Harbeck
U.S. Geological Survey
Denver Federal Center
Building 25
Denver 2, Colorado

10) FRANCE

Le *Bureau de la Section Française de l'AIHS pour la période 1961-62-63* est constitué comme [...]t :

[...]ésident:	M. Auguste VIBERT — Ingénieur général à la Direction Technique des Eaux et Assainissements de la Ville de Paris — 9 rue Schoelcher — PARIS 14° Tél. GOB. 70-00
[...]ce Présidents:	M. Marcel GOSSELIN — Ingénieur général des PONTS & CHAUSSÉES — Ministère des Travaux Publics, des Transports & du Tourisme — 155 rue de la Croix-Nivert — PARIS 15° Tél. VAU. 34-20
	M. Henri SCHOELLER — Professeur de Géologie à la Faculté des Sciences de l'Université de BORDEAUX — 20 Cours Pasteur — BORDEAUX (Gironde) Tél. Bordeaux 859-64
[...]crétaire:	M. Louis SERRA — Chef de la Division HYDROLOGIE du Service des ETUDES HYDRAULIQUES de l'E.D.F. — 6 quai Watier — CHATOU (S. & O) Tél. Paris 966-35-20.

B) UNESCO-OMM

[...]OLLOQUE SUR LES CHANGE[...]ENTS DE CLIMAT ET LEURS [...]FFETS, NOTAMMENT DANS LA ZONE ARIDE

ROME, 2-7 OCTOBRE 1961

[...] ORIGINE ET BUTS DU COLLOQUE

Dans le cadre du programme de l'Unesco [...]latif aux terres arides, des colloques por[...]nt sur des questions en rapport direct avec [...]s recherches relatives à la zone aride (hydro[...]gie, écologie végétale, énergie éolienne et [...]laire, climatologie, problèmes de la sali[...]té, physiologie végétale, etc.) ont été orga[...]sés chaque année avec le concours de [...]fférents Etats membres.

Sur la suggestion de l'Organisation mété[...]orologique mondiale (OMM), le comité [...]nsultatif de recherches sur la zone aride [...] recommandé que l'on organise, conjoin[...]ment avec l'OMM, un colloque sur les [...]angements de climat. L'objet de ce colloque [...]t de réunir des savants, représentant un

B) UNESCO-OMM

SYMPOSIUM ON CHANGES OF CLIMATE WITH SPECIAL REFERENCE TO THE ARID ZONES

ROME, 2-7 OCTOBRE 1961

1. ORIGIN AND AIMS OF THE SYMPOSIUM

As part of Unesco's arid lands programme, symposia on subjects related to arid zone research (hydrology, plant ecology, wind and solar energy, climatology, salinity problems, plant physiology, etc.) have been organized each year with the assistance of different Member States.

At the suggestion of the World Meteorological Organisation (W.M.O.), the Advisory Committee on Arid Zone Research recommended that a symposium on changes of climate be organized conjointly with W.M.O. The purpose of the symposium is to bring together scientists from a number of disciplines such as meteorology, climatology, geomorphology, palaeobotany, etc., who

certain nombre de disciplines telles que la météorologie, la climatologie, la géomorphologie, la paléobotanique, etc. et ayant poursuivi des travaux sur la question, afin de dresser un tableau complet et détaillé des connaissances et des théories actuelles sur les changements de climat et sur leurs effets. Le Gouvernement italien a bien voulu accueillir ce colloque. La FAO, l'Association internationale de météorologie et de physique de l'atmosphère (AIMPA) et l'AIHS ont offert leur collaboration technique pour l'organisation du colloque.

2. Programme

Le programme a été établi conjointement par l'UNESCO, l'OMM et l'Association internationale de météorologie et de physique de l'atmosphère. La première question qui s'est évidemment posée a été de déterminer la période sur laquelle devrait porter l'étude. On a l'intention d'examiner surtout les changements récents survenus au cours de la période historique, sans toutefois exclure les travaux qui ont été faits sur la question pour la période du pleistocène.

La séance d'ouverture aura lieu le 2 octobre; ensuite, une journée sera consacrée à l'examen de chacun des quatre sujets suivants :

I. *Changements survenus au cours de la période couverte par les observations météorologiques* :

La discussion portera notamment sur les indices fournis par les données météorologiques, glaciologiques et océanographiques, ainsi que sur les méthodes d'analyse et les critères à appliquer pour l'évaluation de ces données.

II. *Changements survenus à la fin des temps géologiques et au début des temps historiques* :

La discussion devra porter notamment sur :

a) les techniques utilisées pour l'évaluation des données, y compris la paléobotanique (analyse des pollens et autres éléments), la paléozoologie, la géomorphologie, la dendrochronologie, les mesures des paléo-

have contributed to the subject so as obtain a coherent and comprehensive pict of present knowledge, theories and im cations of climatic change. The Ital Government has kindly offered to act as h for this Symposium. The F.A.O., the Int national Association of Meteorology a Atmospheric Physics (I.A.M.A.P.) and I.A.S.H. have offered their technical co boration in organizing the symposium.

2. Programme

The programme has been establish jointly by Unesco, W.M.O. and the Int national Association of Meteorology a Atmospheric Physics. The first obvious qu tion concerned the period to be covered. It intended that the main emphasis of the sy posium will be on recent changes duri the historical period but not excluding re vant work on the Pleistocene.

Following the opening session which w take place on 2 October, one day will devoted to each of the following four su jects.

Changes during the period of meteorolo- cal records :

Discussion should include evidence pr vided by meteorological, glaciological a oceanographic data, the methods of analy and the criteria to be used in evaluating t data.

II. *Changes during the late geological a early historical record* :

Discussion should include :

a) techniques used in data evaluati including palaeobotany (pollen analysis a relevant material), palaeozoology, geomo phology, dendrochronology, palaeotemp rature measurements (deep sea cores, et and radiocarbon dating.

pératures (sédiments abyssaux, etc.) la datation par le radiocarbone,
b) les indices que ces techniques per-tent d'obtenir sur les climats des époques sées.

Théories des changements de climat

La discussion devra porter notamment les explications possibles des change-its de climat dont on a recueilli des indices la circulation générale de l'atmosphère es océans, y compris les aspects régionaux aisonniers de la question.

Portée des changements de climat

La discussion devra porter notamment l'importance des changements de climat point de vue des ressources en eau, de la morphologie et du sol, de l'écologie étale et animale, et sur leurs effets dans lomaine de l'agriculture et dans d'autres eurs de l'économie.

La séance de clôture sera consacrée ıcipalement à l'élaboration d'un rapport apitulant les points essentiels qui se seront agés des discussions.

Pour chacune des quatre principales stions étudiées, un président de séance a nommé et les présidents seront invités ouvrir la séance par un exposé général.

PARTICIPANTS

L'Unesco et l'OMM inviteront un tain nombre de savants non italiens, nus pour s'être livrés à des travaux sur question. Le comité local d'organisation se argera d'obtenir la participation de spé-listes italiens. On espère en outre qu'un tain nombre de spécialistes pourront ır assister au colloque à leurs propres is ou aux frais des institutions dont ils endent. Le nombre total des participants a d'une centaine au maximum.

COMMUNICATIONS

Conjointement avec les présidents de nce, le Département des sciences exactes naturelles de l'Unesco, Place Fontenoy, ris (7[e]), s'occupera de coordonner les

b) evidence of past climates derived from these techniques.

III. *Theories of changes of climate*

Discussion should include possible explanations of the evidence of changes in climate in terms of the general circulation of the atmosphere and oceans, including regional and seasonal aspects.

IV. *Significance of changes of climate*

Discussion should include the significance of changes of climate for water resources, geomorphology and soil, ecology of plants and animals, and agricultural and other economic implications.

The closing session will be devoted mainly to a review paper summarizing the main points brought out during the symposium.

A session chairman will be appointed for each of the four main fields and each of these chairmen will be invited to start the session with an opening review paper.

3. PARTICIPANTS

Unesco and W.M.O. will invite a number of scientists from outside Italy who are known to have worked on the subject. The participation of Italian specialists will be organized by the local arrangements committee. In addition, it is hoped that a number of specialists will be able to attend at their own or their institution's expense. The total number of participants will be restricted to about one hundred scientists.

4. SCIENTIFIC PAPERS

Together with the session chairmen, Unesco's Department of Natural Sciences, Place Fontenoy, Paris, VII[e], will arrange for the coordination of scientific papers so that

communications qui seront présentées à la réunion afin d'assurer l'équilibre entre les diverses sections du programme.

Les participants qui désirent présenter des communications sont priés d'en adresser le titre accompagné d'un résumé de 250 mots au maximum, en anglais ou en français, au Département des sciences exactes et naturelles de l'Unesco avant le 1er mars 1961. Seules seront acceptées les communications scientifiques originales portant sur les questions inscrites dans le programme; les présidents de séance seront chargés du choix définitif des communications qui seront présentées.

Le texte complet de toutes les communications qui seront présentées oralement au cours de la réunion devra parvenir à l'Unesco pour le 1er mai 1961 au plus tard, afin que l'on puisse en assurer la reproduction et la diffusion avant l'ouverture du colloque.

Les manuscrits des communications devront être rédigés en anglais ou en français; ils ne seront reproduits que dans la version origina'e.

Les participants qui désirent rédiger leur communication en d'autres langues sont priés d'en fournir eux-mêmes la traduction soit en anglais soit en français.

Le texte complet devra être dactylographié et ne pas dépasser 5.000 mots, avec les références, graphiques et tableaux nécessaires. Seules les illustrations photographiques absolument indispensables à la compréhension du texte pourront y être jointes. Les références bibliographiques devront être citées conformément aux règles recommandées dans le document UNESCO NS/AZ/117.

L'Unesco se propose de publier le compte rendu des travaux du colloque dans sa collection *Recherches sur la zone aride*.

5. Date et lieu du colloque

Le colloque se tiendra du 2 au 7 octobre 1961 au siège de la FAO à Rome. D'autres précisions seront données ultérieurement et feront l'objet d'une deuxième note.

the various sections of the programme w
be properly balanced.

Participants of the Symposium wish
to presant scientific papers are reques
to send the title together with a summ
of not more than 250 words in English
French to Unesco's Department of Natu
Sciences not later than 1 March 1961. O
original scientific papers bearing on
programme will be accepted, the final ch
of papers to be presented resting with
session chairmen.

The full texts of all scientific papers
be presented orally during the Symposi
must reach Unesco not later than 1 M
1961 in order to leave sufficient time for th
reproduction and circulation before
opening of the symposium.

Manuscripts of papers should be
English or French, they will be reprodu
only in the original language.

Participants of the Symposium wish
to prepare their papers in other langua
are requested to supply an English or Fre
translation themselves.

The full text must be typed and cont
not more than 5,000 words, together w
any necessary references, graphs and tab
Only such photographs as are essential
the understanding of the text may be attach
Bibliographical references should be give
accordance with the rules advocated
document UNESCO/NS/AZ/117.

Unesco proposes to publish the proc
dings of the Symposium in its *Arid Z*
Research series.

5. Date and Place of the Symposium

The Symposium will be held in Rome
FAO Headquarters from 2 to 7 October 19
Further details will be given in a sec
information note.

D) UNITED Nations

1) WATER RESOURCES DEVELOPMENT CENTRE

New York, 1960

The Water Resources Development Centre of the United Nations published in 1960 a booklet: Large-Scale Ground-water Development.

We reproduced the foreword and the Table of Contents of this booklet.

Foreword

1. In its resolution 675 (XXV) the Economic and Social Council requested the Secretary-General of the United Nations to take appropriate measures for the establishment, within the Secretariat, of a centre to promote co-ordinated efforts for the development of water resources. It also singled out ground-water problems as one of the priority subjects in the development of a programme of studies.

2. *Large-scale Ground-water Development* is the first of a series of studies to be jointly undertaken by the various United Nations organizations participating in the activities of the United Nations Water Resources Development Centre. In July 1959, as a first step in the preparation of the present study, the Centre held informal discussions at the headquarters of the Food and Agriculture Organization of the United Nations (FAO) in Rome with a group of experts and representatives of the interested specialized agencies. These discussions resulted in an annotated outline which was widely circulated for comments among specialists in the various techniques related to ground-water development. Dr. Frank Dixey, Chairman of the Advisory Committee on Arid Zone Research of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and former Director of the British Overseas Geological Surveys, was appointed by the Centre to prepare a preliminary draft which was discussed at a meeting held in New York in February 1960.

3. In finalizing this report the Water Resources Development Centre has thus benefited from the wide experience of the participants in the abovementioned meeting: Mr. François M.P. Bazin, ground-water hydrologist in charge of the ground-water investigation section, Société grenobloise d'études et d'applications hydrauliques (SOGREAH), France; Dr. David J. Burdon, ground-water geologist and FAO technical assistance expert; Mr. John P. Dabell, ground-water development specialist and Chief of Water Resources and Irrigation Branch, representing FAO; Dr. Frank Dixey; Mr. Thomas E. Eakin, geologist specialized in ground water, and Chief, Foreign Hydrology Section, United States Geological Survey; Mr. Benjamin R. Hudson, hydrogeologist-engineer and United Nations technical assistance expert; Mr. Max A. Kohler, Chief Research Hydrologist, United States Weather Bureau, representing the World Meteorological Organization; Mr. Abelardo S. Mañalac, Head Ground Water Unit, Bureau of Public Works, Philippines; Mr. Renato Pavanello, civil (hydraulic) and sanitary engineer, Pan American Sanitary Bureau – Regional Office for the Americas, World Health Organization (WHO), representing WHO; and Professor Verners A. Zans, Director of the Geological Survey Department, including Ground-water Branch, Kingston, Jamaica, West Indies. Credit should also be given here to Mr. R. N. Clark, Chief Sanitary Engineering Adviser Division of Environmental Sanitation, WHO, Geneva, who contributed most of annex II of the present study.

4. The study is divided into an introduction and five chapters, supplemented by annexes of a more technical and detailed nature and a glossary. The introduction delineates the study, with reference to experience gained in technical assistance in the light of advances in ground

water technology and current development. Chapter 1 sets out some basic considerations relatin to ground-water use and deals in turn with economic factors, quantity and quality of wate allocation of ground-water supplies, effective use and conservation, and some social implic tions. Chapter 2 on stages of ground-water development covers the range from hydrogeologic investigation to maintenance. Economic and financial aspects are the subject of Chapter which reviews the elements of costs, the prospective benefits and the types of financing. Chapter considers the role of Governments and the framework for organization and administrativ questions relating to staff and other requirements. Chapter 5 discusses concepts of ground-wat rights and other matters of ground-water legislation.

TABLE OF CONTENTS

This booklet is a United Nations Publication Catalogue No 60 II B. 3 Price 1,25 $.

2) CONFÉRENCE DES NATIONS UNIES SUR LES SOURCES NOUVELLES D'ÉNERGIE

ITALIE 21-31 AOUT 1961

Nous avons reçu un Bulletin d'Information venant de (New York) de cette conférence, dont nous reproduisons l'ordre du jour. Il nous a semblé que la partie relative à l'énergie géoffique pouvait intéresser l'AIHS.

ÉNERGIE GÉOTHERMIQUE

Prospection des champs géothermiques et recherches nécessaires pour évaluer la puissance utilisable :
Description des champs connus
Prospection préliminaire
Recherches en vue de l'évaluation

Exploitation de l'énergie géothermique et production d'électricité au moyen de l'énergie géothermique :
Procédés d'exploitation de l'énergie géothermique; matériel nécessaire
Utilisation de l'énergie géothermique pour la production d'électricité

Utilisation de l'énergie géothermique pour le chauffage; systèmes combinés pour la production d'électricité et le chauffage avec éventuellement extraction de sous-produits :
Chauffage
Systèmes combinés et sous-produits

Examen général et résumé concernant des problèmes et des résultats d'énergie géothermique; séance plénière

A. Energie solaire disponible et instruments de mesure :
Données sur le rayonnement — réseaux — instruments

B. Matières nouvelles employées dans l'utilisation de l'énergie solaire :
Matières plastiques, métaux, verre, surfaces sélectives et autres matières

C. Emploi de l'énergie solaire pour le chauffage :
1. Chauffage de l'eau
2. Chauffage des locaux

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Les 4 tomes ensemble	550		»

Assemblée de Bruxelles 1951

Publ. n° 32 — Tome I — Neiges et Glaces		300	»
Publ. n° 33 — Tome II — Eaux Souterraines et Erosion		250	»
Publ. n° 34 — Tome III — Eaux de Surface		350	»
Publ. n° 35 — Tome IV — Symposia sur Zones Arides et crues		125	»
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Assemblée de Rome 1954

Publ. n° 36 — Tome I — Erosion du Sol, Précipitations, etc.		300	»
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II. BIBLIOGRAPHIE HYDROLOGIQUE

1934 (Egypte, France, Indes, Italie, Lettonie, Maroc, Pays Baltes, Roumanie, Suède, Suisse, Tchécoslovaquie, Tunisie, Pologne — en 1 vol. 100 F Belges

Argentine

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Allemagne

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Egypte

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Yougoslavie

du début à 1954-20 FB.

Hongrie

1945-1954 — 50 FB.

Israël

1945-1949 — 20 FB.
1949-1955 — 25 FB.

III. BULLETIN DE L'ASSOCIATION D'HYDROLOGIE

Ce bulletin paraît quatre fois l'an depuis 1956. Il comprend une partie réservée à l'information et une partie scientifique.

Prix de l'abonnement : 250 FB.

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